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OCEANIC NEGROES.

By R. LYDEKKER.

LIKE many other terms, the word Negro, and more especially its vulgar corruption "nigger," has a popular, and indeed an etymological, significance very different from the sense in which it is employed in anthropological science. Etymologically, of course, it means simply a black man, and is therefore legitimately applicable to all dark-skinned races, of whatever origin; although there is the difficulty of determining where to draw the line between dark and light-skinned races, since there is a complete transition from the one to the other. In this sense, therefore, the dark-skinned races of Somaliland and Nubia may be termed Negroes, although they have a large proportion of Arab blood in their veins. The wild tribes of India and Ceylon, forming the subject of another article in KNOWLEDGE, may likewise be so termed; and, however much they may dislike such an appellation, it is difficult to see how many of the higher races of India can claim an exemption from this use of the name.

But in a scientific sense the term has a much more limited application, although even here difficulties are met with in defining it when we have to deal with cross-bred races like those of North-eastern Africa. If the aborigines of Australia be excepted (and it has been shown in an earlier article that there are some reasons for regarding them as belonging to a different stock), a Negro may best be defined in popular science as a person with frizzly, or, incorrectly, woolly, black hair, and generally a very dark, or even black complexion. The hair is, however, a much better character than the colour of the skin, which in the South African Bushmen is of a leathery yellow. Accompanying this frizzly hair, we may generally notice in Negroes an elongated skull, a broad and flat nose, thick and projecting lips, relatively large teeth, and moderate or scanty development of the beard. Closer examination will reveal the fact that the fore-arm of a Negro is longer in proportion to the leg than is the case in an average European; and there is also less development of the calf of the leg, as well as a marked difference in the form of the heel. But to record all such minutiæ would be practically to write a treatise on anthropology; and I must accordingly ask my readers to be content with the frizzly hair as the essential characteristic of a pure-bred Negro.

Now we all know that such frizzly-haired black (occasionally yellow) skinned people populate the greater part of Africa, whence numbers of them have been transported in the old slaving days to various parts of America. And it is among these black African races that we have the typical Negro of anthropological science, and, probably, also of popular speech. But Negroes, even in the scientific sense, are by no means restricted to what, from an anthropological point of view, may still be aptly designated the "Dark Continent." Frizzly-haired black races are met with in the Andamans and Philippines, as well as in some of the neighbouring islands; but since all these people differ from African Negroes by their broader and shorter heads, they have been separated under the name of Negritoes; and it is not of these that I desire to treat on the present occasion. Further eastwards, in that part of Oceania now commonly designated (from the colour of its inhabitants) Melanesia, we find "mop-headed," frizzly-haired races, agreeing so essentially in physical characters with African Negroes, that there can be no reasonable doubt of their comparatively near relationship to the latter. As some of my readers may perhaps be a little hazy as to the precise signification of the term Melanesia,* it may be stated for their benefit that it includes the great island of New Guinea, or Papua, together with the Louisiades, the Bismark (New Ireland and New Britain) and Solomon groups, the New Hebrides, the Loyalty group, and New Caledonia. The mountains of the interior of Fiji are likewise inhabited by members of the same negro-like race.

In regard to a general name for these Oceanic Negroes, as they are perhaps best called, authorities are somewhat divided. By the Malays the aborigines of New Guinea are designated Orang Papua (pronounced Papooa), and some writers extend the term Papuans to embrace the inhabitants of the whole area. On the other hand, the term Melanesians, originally proposed

* In the "Times Atlas" the name Melanesia, although omitted from the index, occurs in the map of the world, but not in that of the Papuan Archipelago.

for the inhabitants of the islands other than New Guinea, has likewise been employed in the wider sense; and it is this usage, when a general term is required, that is followed here.

A typical Melanesian has the same dark skin as an African Negro, and likewise a similarly elongated skull, whereby he is separated widely from the round-headed Negritoes of the Andamans and Philippines. Indeed, the Kai Colo tribe, of the mountains of Fiji, have longer and narrower skulls than almost any other people. A Melanesian skull may be generally distinguished from that of an African Negro by the heavy ridges over the eyes; these brow-ridges being almost absent in true Negroes. As similar brow-ridges occur among some of the prehistoric natives of South America, an affinity has been suggested between these people and Melanesians, but on altogether insufficient grounds. The jaws in the Melanesian skull are projecting, and the cheek-bones very wide; and since the forehead generally narrows superiorly, while the chin is not very broad, the form of the face very frequently is that of a long oval, pointed above and below. The nose, especially in New Guinea and the adjacent islands, is narrower and more prominent than in African Negroes, and is never of the broad, saddle-shaped type so characteristic of Australians; it is, however, generally low and somewhat broad at the root, tending towards an aquiline type among some of the inhabitants of Yule Island. The mouth is broad and full, but the lips are by no means so protuberant as are those of the typical African Negro. The most striking common feature between Oceanic and African Negroes is the frizzly hair, which is quite different from the wavy locks of either the Australians or the Polynesians, and still more so from the long lank tresses of the Malays. There is, however, a certain difference between the hair of Melanesians and Africans, the former growing in very marked and regular waves, and thus being more like wool than is the latter, which forms an uneven tangled mass. His hair is indeed the strong point of a Papuan, and it is often dressed and frizzed till it stands out in a mop-like manner on all sides. Feathers and the tails of kangaroos are employed for its decoration, and combs for its dressing. Only in cases of serious illness do the men cease to attend to their hair; but in the girls it is kept shorter, and in some tribes the married women cut it quite short or even shave it off. On the other hand, the men are careful to pluck out every hair from their beards, and sometimes extend the operation to their eyebrows. As regards their muscular development, Melanesians display a powerful build in the upper part of the body, the shoulders being broad and the arms strong; but there is a woeful falling off in the lower extremities, which, especially in the men, are long and thin, with very small calves.

Turning to the consideration of the affinities of the Melanesians, there seems every reason for regarding them as a pure-bred race, which has no intimate relationship with their near neighbours the Malays. The form of their heads likewise separates them from the Negritoes of the Andamans and Philippines. But in this latter respect, as well as in the character of the hair, they come so close to the African Negro, that there can be little hesitation in regarding both races as derived from a common ancestral stock, notwithstanding the birth-place of such stock cannot be determined. That the date of divergence of the two races must be very ancient, seems evident from the absence of any common feature in their language.

More difficult is the question of their relationship to the Australians, Tasmanians, and Polynesians. With regard to the former, as stated in a previous article, I am inclined to agree with Dr. Semon that they have no direct kinship. If this be so, the extinct Tasmanians can scarcely any longer be considered as pure but aberrant members of the Melanesian group; and we may perhaps regard them, with Dr. Semon, as having originated from a crossing between the inhabitants of Australia and immigrants cast by chance into those regions; such immigrants being presumably Melanesians.

As already mentioned, the mountains of the interior of Fiji are inhabited by frizzly-haired Melanesians; but the lowland population of that group of islands is formed by the wavy-haired people known as Polynesians. And these Polynesians extend over the whole area from which they take their name, being represented in New Zealand by the Maori. Now it is generally admitted that the Polynesians have a certain

amount of Melanesian blood in their veins; and it has been supposed that the whole of Oceania, from Flores eastwards, was originally populated by frizzly-haired Oceanic Negroes, whose descendants in Polynesia have been so profoundly modified by crossing with an immigrant type as to have formed practically a new race. If we ask who were the immigrants, the most probable answer is Malays. And that such a mixture would produce the Polynesians, as we now know them, was the opinion of the late Sir W. H. Flower. And in a modified degree this appears also to be the view of Dr. Semon, who, after stating that if Melanesians and Polynesians be more closely related than is commonly supposed, writes that this "would only show Polynesians to be a branch of the Papuan race, which, by admixture with other races, principally Malays, and by a subse-

quent independent development, has become developed into what may be termed a new type." It is added that, apart from a Polynesian immigration into South-eastern New Guinea (which does not affect the question), "a relation between Papuans and Polynesians cannot be absolutely denied." And some observers have even gone so far as to assert that, with the exception of the difference in the hair, there is very little physical distinction between typical Polynesians, such as the Samoans, and pure-bred Papuans.

On the other hand, it has long been noticed that many Polynesians, and more especially the Maori, exhibit a decidedly Caucasian type of feature, and hence it has been inferred that the immigrant stock which has produced the present race by fusion with the original Melanesian element was Caucasic rather than Malay (Mongolian). The fact that the Polynesians generally have straight black, rather than wavy hair, is one among several circumstances that makes me incline towards the Malayan theory.

But by this time my readers must be getting tired of discussions on phylogeny; and I must accordingly say something in regard to the character and status of the Oceanic Negroes. And here it is well to mention that Negroes of all descriptions stand on a much higher platform of intelligence than people like the Australians or Veddas; their faculties being indeed capable of a comparatively high degree of development, although their political organisation is at a low grade.

We are, it is true, accustomed to regard the Papuans as cruel and bloodthirsty savages, but this, according to Dr. Semon (from whose observations the greater part of the remainder of this article is compiled), is far from being a correct estimate of their general character. It is true that the Papuan is hideously cruel in warfare, subject to passionate outbursts of uncontrollable fury, unreliable in his dealings with the foreigners with whom he is brought in contact, and eager to possess himself of valuable or desirable property in the hands of strangers. But he is essentially a creature of impulse, and it is this impulsive nature which leads to his proneness to murder and rob his fellow man. His paroxysms of rage are, however, short-lived; and in his normal condition he is bright, gay, and harmless, displaying great kindness in the treatment of his wife and family, and mourning for his lost relations in a way that marks him as possessing humane feelings of great intensity. Living in a country and climate where he has but few wants except food, and much of the latter being procurable with comparatively little exertion, he is naturally not prone to hard work, leading a kind of lotus-eating existence, whose calmness is only disturbed by tribal wars, or by hostile outbreaks against the foreigner.

Having thus a large amount of time at his disposal, and being apparently inclined by nature towards the cult of the beautiful and the ornamental, the Papuan turns his attention towards the decoration of his home and domestic implements and utensils. His artistic efforts cannot be compared with those of civilized nations; still, the ingrained love of decoration and ornamentation seem to be more highly developed than in any of the latter. For, as Dr. Semon remarks, do we ever find the European boatman carving and decorating his oar, the carpenter his adze, or the husbandman his plough. And yet every Papuan implement and weapon (and they are too numerous to refer to in detail on this occasion) bears witness to the artistic power and patience of its owner; while not less noteworthy is the attention paid to the decoration of the person. However, Papuan and European ideas of what is becoming in the latter respect are by no means identical. As regards their fondness for personal adornment, both sexes of Papuans present a remarkable contrast to their Australian neighbours; while in respect to their weapons and implements there is, of course, no sort of comparison between the two races. Not the least noteworthy circumstance is the absence among the Papuans of the one really effectual Australian weapon—the boomerang; this alone being almost sufficient to indicate that the two races have no close relationship.

The Papuans are to a great extent a coast-dwelling people, the greater part of the mountainous interior of their island, except on the lines of the great rivers, being uninhabited. The chief pursuits of the men are hunting and fishing, together with sailing; but they are in the habit of taking long voyages, when rough seas must at times be encountered, nevertheless their fishing is always conducted during fine weather. The women, on the other hand, undertake all the duties of the home and the plantation; those living in districts where the necessary material is obtainable, manufacturing pottery for household and other purposes. Liberty and individual freedom seem as essential to the Papuan as to the Briton; chiefs, of a kind, are recognised, but their sole duty is in connection with foreign affairs. This characteristic freedom is doubtless one cause of the objection of the Papuans to hard work, especially carrying burdens, for which they are indeed physically unfit, being absolutely incapable of bearing half the loads carried with ease by African Negroes.

Neither can the Papuan be credited with the attributes of a bold or fearless warrior; the natives of British South-east New Guinea are stated to be more courageous than those of the northern German and Dutch districts. Indeed, cases have been recorded of voluntary self-sacrifice on behalf of a comrade, yet Papuan warfare is generally characterised by treachery, and ruthless slaughter or torture of the members of other tribes taken by surprise, together with the massacre of defenceless women and children. Cannibalism is also a recognised practice.

Dr. Wallace regards the Papuans as intellectually equal, if not superior to their Malay neighbours, an opinion which is not shared by the majority of observers. Dr. Semon, for instance, considers their intellectual standard far above that of the Australians, but decidedly inferior to that of the African Negro, which, under the favourable circumstances existing in America, he is inclined to rank rather high. Compared with his Polynesian neighbours, the Papuan schoolchild is indeed stated to be decidedly inferior; and this mental inferiority apparently persists throughout life.

As regards marriage customs, the peculiar prohibitions of intermarriage between even distant relatives which forms such a characteristic feature of the Australian aborigines, are conspicuous by their absence among Papuans in common with Melanesians generally; and this, again, so far as it goes, serves to accentuate the great gap between the latter and Australians. Polygamy is the recognised custom throughout Melanesia; and, as is generally the case under such conditions, the marriage tie is easily loosed. Mourning customs are very strictly observed everywhere, while in many parts of New Guinea the images of their ancestors appear to receive a kind of worship from their descendants; religion, however, sits but lightly on the Papuan; and among the south-eastern tribes it is even doubtful if belief in a supernatural being exists at all.

XUM

But ancestor-worship may be taken as presumptive evidence of the idea of a future existence; and we may perhaps best define the Papuan religion as in a rudimentary condition. Belief in sorcery and witchcraft is rampant; and both sickness and lunacy are regarded as due to the latter influence.

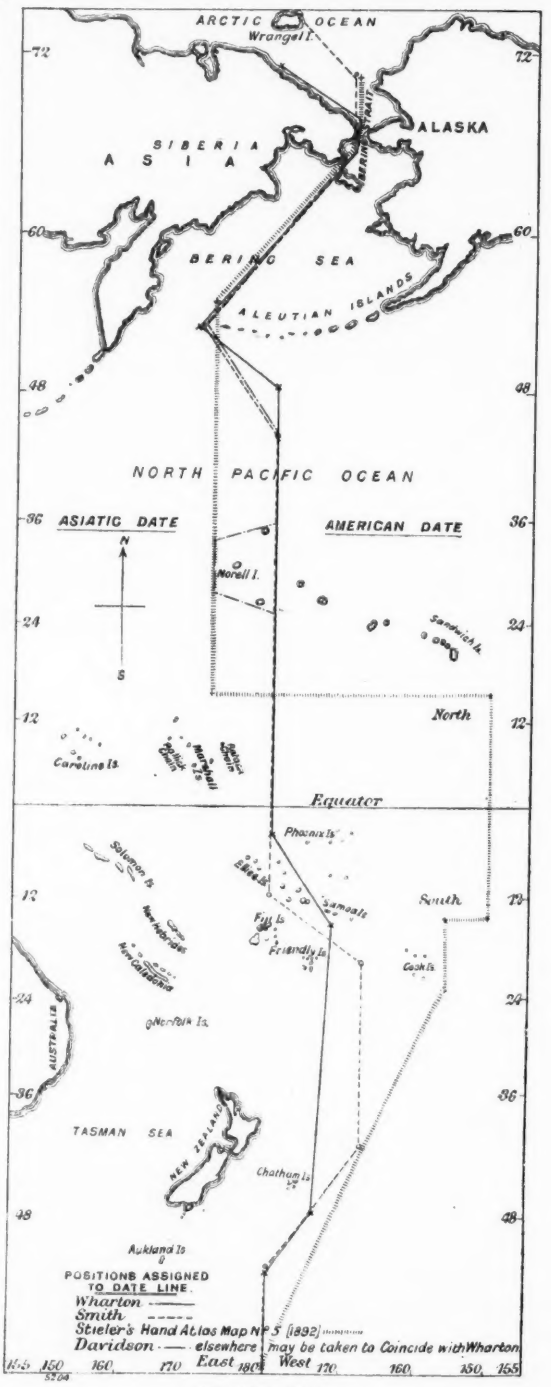
In certain districts tatooing is practised; but, with the exception of the short skirts of fibre worn by the women, the wardrobe of a Papuan is of the most limited description; the adornment of the hair being the chief sacrifice to fashion. It should, however, be added that the cartilage of the nose is frequently perforated to contain a boar's tusk, or a long pin cut from the giant clam (Tridacna), while shells of various descriptions are also worn as ornaments. No account of the Papuans would be complete without some reference to their pile-dwellings, which recall the habitations of the ancient Swiss lake-dwellers. These pile-villages, which are built in sheltered bays and supported on mangrove stems, are generally surrounded by water at high tide, but left more or less completely dry at the ebb. The coast tribes, who are in constant fear of those living more inland, are accustomed to escape from an attack by taking to their canoes before the enemy has time to gain access to their houses. But, as Dr. Semon remarks, in respect to the villages of Port Moresby, "the advantage of the plan seems impaired by the circumstance that the desired protection is rendered futile during ebb-tide, and I am sure that the wisdom of even a Papuan chief-commander will lead him to defer his attack till low water. Moreover, the inhabitants of Port Moresby are known as valiant warriors, and it is perhaps owing to ancient tradition rather than to fear of their enemies that they build their houses on piles and into the sea, never giving a thought to the original reason of this system."

WHERE THE DAY CHANGES.

By Dr. A. M. W. Downing.

Crossing the line for the first time must always be an experience of great interest to the traveller. Indeed, in former times the experience must have been a very disagreeable, as well as an interesting one, on account of the unpleasant character of the ceremonies that were considered appropriate to the occasion, and in which the tyro took unwillingly somewhat too prominent a part. In the bad old times to which I refer, people were known sometimes even to speak disrespectfully of the Equator.

But the Line of which I wish to speak—with entire respect—on the present occasion is not the Equator, but a line, in the neighbourhood of the 180th meridian, on which the day changes for the portions of continents and the groups of islands that lie thereabout, and which is, in consequence, called the Date Line. It is scarcely necessary to point out that to the Eastward-going traveller the local time is ever later and later, whilst to the Westward-going traveller it is ever earlier and earlier, than the time of the initial meridian. So that when the traveller, in the first case, reaches the 180th meridian his time is twelve hours later than that of the 1st meridian, and when the traveller, in the second case, reaches the same meridian his time is twelve hours earlier. The respective times of the two travellers (supposing them to meet on the 180th meridian) differ therefore by a day; that of the one coming from the Asiatic side being a day later than that of the one coming from the American side. When it is Thursday (suppose) on the American side, it is Friday on the Asiatic side. To set things right it is necessary for the traveller coming from the American side—in the case supposed—to skip Friday altogether, and to pass from Thursday to Saturday, whilst the traveller from the



The Date Line.

Asiatic side must have two "Fridays" in succession. This is the practice followed on board ocean-going ships when crossing the 180th meridian, and is as interesting

an experience, in its way, as that of crossing the other "Line," to which I have alluded above.

But are not these things written of in "Tramps Abroad," and other such literature? They need not, therefore, be further dwelt on here, as the matter to which I wish particularly to draw attention is the actual position of the Date Line in its course from the Arctic to the Antarctic regions. This is necessarily affected by the configuration of the continents, and by the groups of islands contiguous to the 180th meridian. But it is obviously most convenient that the Date Line should follow that meridian as closely as political and geographical circumstances will admit. The positions of the Line, as assigned by the different authorities I have been able to consult, are laid down on the accompanying map, which is reproduced, by permission, from the "Journal of the British Astronomical Association," Vol. X., No. 4. The first thing that strikes one on looking at the map is the divergence of the different authorities. Notably the position given in Stieler's Hand Atlas is discordant, and, at the same time, deviates most from the 180th meridian. The Atlas is, however, dated 1892, and this position may perhaps be considered, if not obsolete, at least obsolescent. The line marked "Wharton" is due to Admiral Sir W. Wharton, the Hydrographer of the Navy; that marked "Smith" is taken from an article in the "Century Magazine" for September, 1899, by Mr. Benjamin E. Smith; that marked "Davidson" is due to Professor Davidson, of the University of California. It will be remarked that Wharton and Davidson agree very closely, except in one or two unimportant details, affecting a small group of islands. By adopting either of these lines, it may be assumed, with some confidence, that we know "Where the Day Changes," except, indeed, for the group of islands referred to, for which we must, I fear, for the present remain in doubt.

The further assimilation of the Date Line to the 180th meridian, though desirable, is difficult of realisation, as the position of the Line depends on the configuration of the parts of Asia and America concerned, and on the various circumstances which determine the direction in which the different groups of islands have intercourse with the outer world. But, judging from the past, progress in that direction, though slow, is sure, and will eventually give us a better approximation to a "straight" Date Line than we have at present.

Would it be to inquire too curiously to ask where the twentieth century begins? As to when it begins, we have recently, somewhat to my astonishment, had a Battle of the Centuries, in which one at least of the crowned heads of Europe has taken a side, and has taken the wrong side too!

The answer to the question, Where does the day change? also answers the question, Where does the century begin? And, as we have seen, a fairly definite reply can be given by a reference to the map, except in the case of a certain group of islands. When does the century change for that particular group? Ah, well! it would puzzle even a crowned head to answer that question.

PLANTS AND THEIR FOOD.—III.

By H. H. W. Pearson, M.A.

Carbon, the most abundant constituent of the plant's food, is drawn from the atmosphere in the form of Carbon dioxide.* Equally necessary, however, are the mineral elements supplied by mother earth. Of these the following are indispensable to most green plants—Phosphorus, Sulphur, Potassium, Magnesium, Calcium and Iron; further investigation may show that others are also essential in certain cases. For the comparatively few plants whose food requirements have been carefully examined these elements comprise all the mineral food requisite to support vigorous growth. Nevertheless, others, although they appear to play no direct role in the process of nutrition, are also absorbed.

These elements are stored in boundless quantities in the rocks of the earth's surface. In the ordinary processes of Nature the rocks are disintegrated and their fragments contribute to the formation of a loose carpet in which the roots of plants grow and extract therefrom a portion of their food. This is the soil, consisting usually of a mixture of rock-particles, disintegrated and partly decomposed, with humus (vegetable mould), an organic substance resulting from the partial decay of the dead bodies of plants and animals. This summary definition of soil is, be it noted, very far from conveying an adequate idea of its exceedingly varied structure and highly complicated nature. It is only quite recently that any serious attempt has been made to grapple with the enormous difficulties confronting the investigation of its structure and properties, with which the supply of plant food is very closely connected; until they are better understood our knowledge of the mineral food supply of plants must remain very imperfect. The chemical and physical properties of the soil are now being carefully studied, particularly in the United States; in this country and in Germany much has of late been discovered concerning the work of living organisms in the soil, more directly in connection with the preparation of the compounds from which Nitrogen, one of the most important constituents of the food, is obtained.

That soils differ from one another in a very marked manner is a fact easily demonstrated. Differences, for example, between the stiff clays of Suffolk, the sands of Bedfordshire, and the Buckinghamshire chalk, cannot be forgotten by one who has walked over them in wet weather. If specimens of these soils are dried and analysed it is found that diversity in chemical composition is much less than would be expected. The same elements are present in them all, and in proportions not varying much from one to the other. The distinctive characters gratuitously forced upon the notice of the pedestrian are due to their dissimilar behaviour towards water. This depends upon their physical properties, the relative sizes of the constituent particles, and not the elements the particles contain, for these are the same in all.

An analysis of a soil shows that it is composed of a great many substances; some are of no importance to plants. Those substances a plant demands from the soil it grows in are Potash, Lime, Magnesia, Iron, and Phosphoric and Sulphuric Acids (the latter in the form of phosphates and sulphates respectively). In addition to these, plants also take up others, for example, Silica and Soda, which appear not to form a necessary part of the food supply. Silica, indeed—and this is true of many other substances as well—is harmful to the plant if absorbed in too great quantity. The large quantities of Silica present in the external cells of grasses and some other plants—responsible for the "cutting edge" of many grass-leaves—are really rejected matter deposited by the plant in the outer cells to be out of the way, this being one of the few methods available to vegetable organisms of disposing of useless solid matter.

* Knowledge, March, 1900.

The most abundant constituent of almost all soils is Silica, of which quartz is a well-known form; as a rule it constitutes from 70 to 90 per cent of their bulk. Its preponderance is due to its insoluble and indestructible character, for, unlike most of the other constituents of rocks, its composition is quite unaltered by long exposure to the atmosphere. It exists in the soil in the pure state and in innumerable combinations with other elements known as silicates. The latter are nearly all as insoluble in water as is Silica itself. Silica and the insoluble silicates cannot be absorbed by the roots of a plant, for these are only able to take in liquids and substances held in solution. The greater bulk of the soil—viz., that part of it consisting of Silica or insoluble silicates—is therefore unable to contribute directly to the mineral food supply of plants. Every solid particle is indirectly concerned in the supply of water to the roots, in the absence of which no food can enter them, and therefore even the innutritious Silica holds an important post in the plant commissariat. In addition to Silica, nearly all soils contain small proportions at least of the essential substances named above, and these must all be accessible to the roots of a growing plant. Very small quantities of the latter will suffice, because they are all dissolved in the soil-water, which is a means of transporting them from any area containing them in abundance to another where any of them may be deficient; another reason is that the amounts actually required by growing plants are remarkably small. The following figures will bear out this statement, at least for the plant they refer to. It has been found that to produce 100 grammes (dry weight) of the Oat plant, it must be fed with the following quantities of the essential mineral substances:—†

	Grammes.
Phosphoric Acid	0·5
Potash	0·8
Lime	0·25
Magnesia	0·20
Sulphuric Acid	0·20
Total	1·95

These amounts are sufficient to enable the plants to grow. As a matter of fact, 100 grammes of the Oat plant contain, as a rule, about 3 grammes of mineral matter; in other words, the plant absorbs about half as much again as is necessary to support its growth. This extra quantity can to some extent be supplied by mineral matters other than those constituting the food proper. With this exception the plant refuses to recognise any attempt to replace the needful substances of its mineral food by compounds containing other mineral elements. If one essential substance is absent, or is present in too small quantity, then not only does the plant absorb a less quantity of that which is deficient, but also of all the other constituents of its food. In fact, a lack of one of these ingredients has the same effect as if the whole food supply were wanting in the same degree. As one imperfect wheel throws a watch out of gear so a shortness in the supply of one food constituent upsets the nutrition of a plant. It seems as if the appetite of the plant must be partly satisfied by definite quantities of certain mineral components—those we have called "essential"—under no circumstances replaceable by others; at a certain stage it becomes less fastidious, and although it demands a further supply of mineral food it is able to select it from a wider range of substances.

† Emil Wolff, quoted by Maercker; Berichte. 1897.

Lime is one of the most important constituents of soils. "A limestone country is a rich country," as the saying has it. The plant uses it not only as food, but also as medicine, or, rather, poison antidote, an edifying fact which will be noticed again. One of the numerous parts played by Lime in the soil is interesting as bearing upon the absorption of soluble silicates by plants. Silicate of Potassium, one of the very few silicates soluble in water, is present in most Clay soils and absorbed by roots. Excess of Silica has an injurious effect on plants. In the presence of certain compounds of Calcium—Lime, for example—Potassium silicate is decomposed, resulting in a Silicate of Calcium, insoluble, and the Silica it contains is therefore unable to enter the plant. Lime is, therefore, a very valuable constituent of Clay soils, since it prevents an undue amount of Silica being absorbed by the plants grown upon them. In some of its forms Lime is very soluble in water, and when present in the soil may be continually washed out by rain; to such an extent does this occur that the soil even of a limestone country frequently contains very little of it. A remarkable illustration of this is furnished by the soil of the Bermuda Islands. The Coral and Shell Limestone of these islands contains 54.5 per cent. by weight of Lime; during the disintegration of the rock, so much lime is carried away in solution that it constitutes less than 4 per cent. of the soil.‡

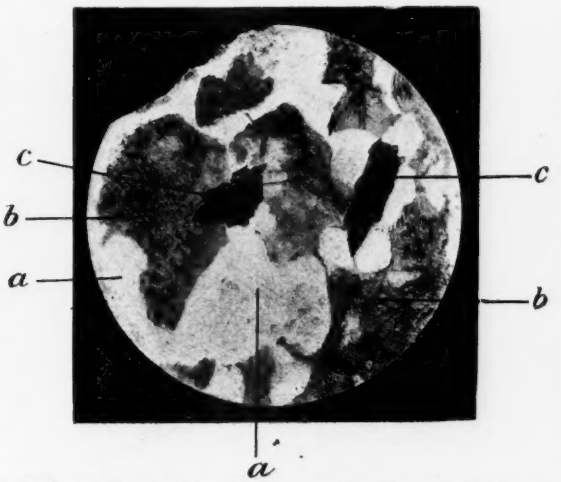
Since differences in chemical composition do not, as a rule, explain the varying degrees of fertility possessed by soils, to what then are they due? They must be ascribed to three principal causes hitherto very incompletely studied. There is, in the first place, the condition in which the food constituents are met with in the soil. In a fertile soil they are presented to the roots in sufficient quantity and in a soluble form in which they are easily absorbed. On the other hand, they may be so locked up that the plant is unable to extract as much as it requires in the time at its disposal—that is, during its growing period. This is often caused either by the soil-particles being insufficiently comminuted or by the insoluble nature of the compounds of which the essential elements form a part. Roots are of course made up of cells, and, as we have seen, plant cells are so constructed that only fluid materials can enter them. Plants, therefore, can obtain no mineral substances from the soil which are not soluble in the soil water, containing Carbon dioxide and other acids derived from living roots and from decaying vegetable matter.§ If the essential mineral ingredients are present in the soil in such a state that they can be neither decomposed nor dissolved by the soil water, assisted by the acids it contains, they are of no use to the plant. The barrenness of Granite crags is well known to all who have visited them in Scotland or elsewhere; and yet Granite contains all the mineral food that a plant needs. It is composed of three important minerals (see Fig.), Quartz (A), Felspar (B), and Mica (C).

Felspar and Mica contain the mineral constituents of plant food, but in Granite these minerals are enclosed in a network of Quartz, the insolubility of which has already been noticed. As long as the network is entire the nutritious constituents of the Felspar and Mica are so locked up that plants cannot get at them. When the

‡ "Rocks, Rock-weathering and Soils." Merrill. p. 359.

§ It was formerly stated that the solution of mineral substances in the soil was largely due to the action of acids set free by living roots. It is now believed, however, that CO_2 and, in a few cases, the acid Phosphate of Potassium, are the only solvents which roots evolve.

Granite, in the natural processes of disintegration, becomes sufficiently broken up, the Felspar and Mica are



A Section of Granite from Skiddaw, × 45. (Reproduced || from a slide in the Woodwardian Museum, Cambridge, by kind permission of Prof. T. McKenny Hughes, F.R.S.) A, Quartz; B, Felspar; C, Mica.

exposed to the action of the atmosphere, and in consequence are decomposed, and from the products of their decomposition a fertile soil is formed.

A second very important factor in the fertility of the soil is the climate. It is the experience of planters and farmers all the world over that in a propitious climate almost any soil is fruitful, a fact partly though not entirely due to the direct effect of a favourable climate upon the vegetation. The effects of different degrees of rainfall, temperature, sunshine, and other influences included in the term "climate," upon the soil are exceedingly diverse, and very imperfectly understood. In some parts of the world where the climate changes very suddenly in passing between two places situated within a few miles of one another, corresponding changes in the fertility of the soil appear to be due entirely to climatic differences. In the central plateau of Ceylon, for instance, there are several remarkable isolated peaks rising to 2,000 or 3,000 feet above the general level of the country. The eastern slopes are, as a rule, preferred by tea planters, because the soil is found to be more fertile than on the western side. The difference is undoubtedly to be attributed to the climate, though the precise manner in which the soil is affected by it is not well understood. The western slopes of these hills are subject at certain seasons to the biting winds of the South-west monsoon, and are very constantly enveloped in mist; on the opposite side the winds of the North-east monsoon are less injurious to vegetation and the sun is much less obscured by cloud. When the slopes were covered by virgin-forest these conditions caused a more luxuriant vegetation to exist on the eastern faces than on the western, and in consequence the soil on that side was more copiously enriched by humus one of the most important contributors to fertility in a soil. This is by no means the only way in which the soil is affected by climatic differences. These have an important effect upon the decomposition of the soil-particles continually taking place in order to make up the deficiencies caused by the demands of existing and increasing vegetation. To what extent and in what manner the climate influences this process are questions which have as yet received no very clear answers, and a consideration of them is too wide for our present limits. Rain is also an important fertiliser of the soil, for it adds to it the "impurities" swept down out of the atmosphere, and in many cases brings down solid matter from the land at higher levels. It has been proved that a very large proportion of a plant's mineral needs can be satisfied by the substances chiefly in the form of dust thus carried down from the atmosphere.

The capability of a soil to support vegetation is also in a very important manner due to its power of retaining part of the water falling upon it as rain. This depends partly upon the size of its mineral particles and also upon the amount of humus (vegetable mould) it contains. Humus has a very strong avidity for water, and largely increases the water-holding power of the soil. It has been said, probably with truth, that, from the point of view of the plants it supports, the most important property of the soil is its behaviour towards moisture—in other words, the relative amount of water it is able to hold by capillarity. The characters of the water thus retained, and some interesting facts concerning the food substances held in solution, remain for further consideration.

|| From a microphotograph kindly taken for this paper by Mr. H. Stanley Jevons, F.G.S.

A TEMPLE OF SCIENCE.

By W. Alfred Parr.

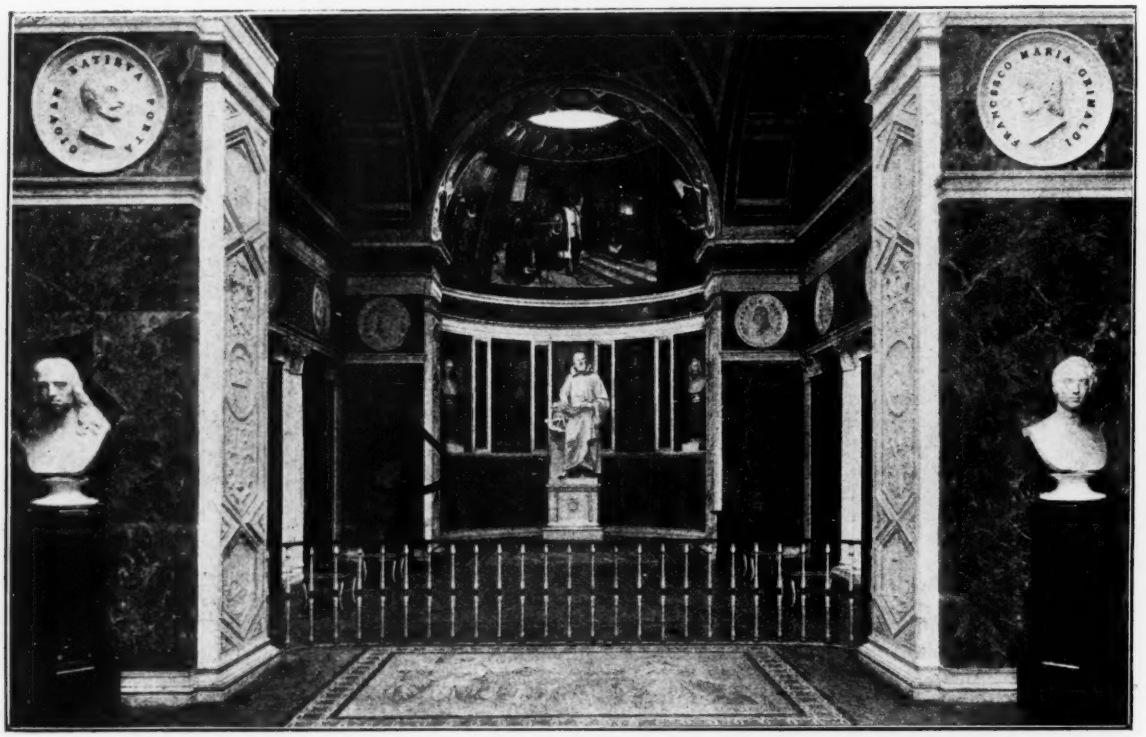
Among the many museums and galleries, filled with the priceless treasures of past generations, with which Florence abounds, and which render the city of Dante a veritable "Mecca" alike to the artist and the student, perhaps none offers a greater interest to the scientific, and more especially the astronomical, visitor than that Temple of Science known as the "Tribuna di Galileo." This richly decorated hall, in which are worthily enshrined some of the most interesting and valuable scientific relics relating to the life and work of Galileo, and which vies in point of interest with the picturesque old tower known as Galileo's Observatory, described by me in a former number of Knowledge,* forms part of the Museum of Physical Science, and was inaugurated in 1840, on the occasion of the assembly at Florence of Italy's principal scientific men. Dedicated, as it is, to the memory of the great Tuscan astronomer, it was but fitting that the structure itself, as well as the paintings, sculptures, and mosaics with which it is so richly adorned, should be representative of the best talent of Tuscany; and that the artists entrusted with the erection and decoration of this memorial to their illustrious compatriot succeeded in worthily acquitting themselves of their task, may be seen from the accompanying photograph.

On every side are depicted interesting episodes in the life of Galileo, from the time when, as a young student, he watched the swinging lamp in the Cathedral of Pisa, to the time when, old and blind, and in the retirement of his villa at Arcetri, he dictated the account of his researches to his two celebrated pupils, Torricelli and Viviani; while in the centre of the apse, dominating the whole, stands Professor Costoli's statue of the great astronomer. The painting in the ceiling immediately

* *See* Knowledge for July, 1899, p. 157. The tower is now the property of Count Paolo Galletti.

above the statue, and plainly visible in the photograph, represents Galileo in the act of demonstrating the merits of his newly constructed telescope to the assembled senate at Venice.

Ranged along the walls are glass cabinets, containing many valuable instruments dating from the time of Galileo and his School, but it is in the two cabinets on either side of the statue that our chief interest centres. In the one to the left of the spectator is preserved, carefully mounted in an elaborate hexagonal frame of worked ivory and ebony, the object-glass which Galileo fashioned with his own hands. This precious bit of glass, if one may believe the Latin inscription on the frame, afforded the great astronomer his first glimpse of Jupiter's satellites, and thus enabled him to announce to the world the great discovery which firmly established



The Tribuna di Galileo in the Museum of Physical Science at Florence. (Photo by Alinari, Florence.)

the Copernican doctrine, and which elicited Kepler's famous message of congratulation to his fellow worker, parodying the last words of the Emperor Julian: "Galileo vicisti!"† The little lens, barely an inch and a half in diameter, which sufficed to reveal the four "Medicean Stars" to the eye of the "Tuscan artist," compares strangely with the great thirty-six inch object-glass on Mount Hamilton which, two hundred and eighty-two years later, added a fifth member to the little group forming the Jovian system. Preserved in this same cabinet, and just discernible in the photograph above the frame containing the object-glass, are two of the first telescopes which Galileo is said to have constructed.

A somewhat gruesome relic of the great man is preserved in the cabinet to the right of the spectator. Mounted on a short marble pillar, adorned with the usual allegorical Latin inscription, is a crystal vial containing the index finger of one of Galileo's hands. It was severed from his body just before the latter was consigned to its last resting place beneath the grand monument prepared for it in that Westminster Abbey of Florence, the Church of Santa Croce.

The remaining cases contain a valuable collection of astronomical, nautical, and geodesical instruments formerly belonging to the Accademia del Cimento, the famous institution which, rising as it were, from the ashes of Galileo, counted among its members such men as Borelli, Viviani, and Redi, and which chose for its motto the significant words, "Provando e Riprovando."

Some old telescopes with wooden "bodies" by Torricelli of Florence, dating from the year 1644, together with others in quaint leather coverings, embossed with curious gilt ornamentations, constructed by Campani of Rome in 1666, are also preserved here and serve to complete a collection which, alike to the student and the antiquarian, is of absorbing interest throughout.

† "Galilean, thou hast conquered!"

ASTRONOMY WITHOUT A TELESCOPE.

By E. Walter Maunder, F.R.A.S.

IV.—A TOTAL SOLAR ECLIPSE.

It is the misfortune of the British Isles to be so completely shunned by total eclipses of the sun that a century and three-fourths has passed since the last visible in England, and more than a quarter of a century has still

to run before this country will be favoured with the next.* Yet the ease of modern travel brings the phenomenon within the reach of so many that it may be well worth while to glance at the various kinds of work which can be undertaken by "astronomers without telescopes," especially as we are now within a month of the time of an eclipse the track of which may be reached by a three days' journey from our own shores.

It should be borne in mind by all who are favoured with a good view of so rare a phenomenon as that of a total eclipse of the sun, that there is a kind of moral obligation upon them not to let the opportunity pass entirely without profit. "The giddy pleasure of the eye" is no excuse for selfishness. Each one should do something, make some record, which may hereafter be of service to others in the solution of some of the problems which are eclipse presents. We owe an inestimable debt to those who preceded us who did leave such records, and we can only repay that debt, by in like manner, doing our best to leave material as useful for the benefit of those who shall in their turn succeed to us.

First of all, the most obvious work for anyone to undertake, who watches a total eclipse without a telescope, is to draw the corona. This may seem a very trivial matter, and when the strange discrepancies between different sketches are noted, a very useless thing to attempt, especially in view of the entrance of photography into the field. But it is not so. The chief fact that we have as yet established with regard to the corona is that it varies in form and character with the sun-spot cycle, and this fact, though supported by the photographs, was demonstrated by the comparison of drawings. Then again the careful examination of drawings has shown them to be far more trustworthy than a cursory look would suggest. The wide differences between different sketches has often been due to the sketchers choosing different sections of the corona; one choosing the brightest inner corona, another the fainter and more irregular contour, a third the faintest extensions. The results have really not been contradictory but rather supplemental of each other. Nor has photography entirely superseded the work of the sketcher even yet. The coronal streamers, often shown in drawings, were photographed in the eclipse of 1898 for the first time. The previous failure of photographs to record them had occasioned their very existence to be denied in some quarters, and had cast unmerited suspicion upon the drawings which delineated them.

The work of drawing the corona is, however, not one to be done off-hand. The intending artist should be one who has already acquired skill and quickness in draughtmanship. The time of an eclipse is terribly short—it will scarcely exceed one minute at most stations on May 28th next—and the object is bizarre and unfamiliar. There should be frequent practices beforehand, either upon drawings of the corona, held at a distance of 107 times the diameter of the eclipsing moon, or, perhaps better, upon little wisps of cirrus cloud. But in any case the time from the first sight of the object to the completion of the sketch must be rigidly confined to the time of the expected duration of totality. Quickness to see and record is the first essential for coronal sketching.

The next point to be noted is the need for fiducial lines by which to orientate the drawing. This may be done by providing a plumb-line right across the line of sight. If the weight at the end of the plumb-line dips into water, it will serve to steady it against vibration with the wind. Mercury, distant about $2\frac{1}{4}^\circ$ from the sun, in the forthcoming eclipse, will supply a further and most excellent reference point both for direction and distance.

If several sketchers can combine they should portion out the corona between them before the eclipse begins, the vertical line being adopted as one of the dividing lines, and if four workers are present, a line parallel to the horizon might be another, thus giving each observer a quadrant. A fifth observer might make a rapid outline of the entire corona as a basis for combining the four quadrantal sketches. In so short an eclipse it would be a distinct advantage to be able to confine the attention to a portion only of the phenomenon.

The sketchers should be careful to indicate as precisely as possible the positions of any red prominences, as these can be verified either from photographs or from observations with the spectroscope. Distances from the limb of the dark moon should be carefully estimated in terms of its diameter.

In some former eclipses, notably in 1873, the brightest inner corona has been screened off by means of a black disc, so as to leave the eye more sensitive for the detection of faint coronal streamers. This is not recommended as it is a troublesome and very doubtfully useful device. But all intending sketchers should be most careful to avoid dazzling their eyes during the coming on of the partial phase, and should rest them as much as possible shortly before totality.

White chalk on purplish blue paper is an admirable material for representing the corona. Notes as to any colour or colours perceived in the corona should be made.

Quite another class of work may be taken up by those who have keen eyesight, in the search for stars. The sun is in a specially rich portion of the heavens, during the eclipse of May 28th, near Aldebaran and the Pleiades, and a great number of stars should consequently be seen. Orion, Sirius, Procyon, Castor and Pollux are all well placed. Mercury is only $2\frac{1}{4}^\circ$ distant from the sun below it; Venus practically at her greatest brilliancy will be nearly in the zenith. To note which stars are seen, when they are first glimpsed, and when lost, would be of some value as a register of the clearness of the sky, and of the brightness of the eclipse, as well as for comparison with the records of old eclipses wherein the appearance of stars was observed.

The zodiacal light should be looked for, for though the chances against seeing it are very great, a single clear record of its appearance during an eclipse would be of the utmost value, and might decide at once whether its axis coincided with the ecliptic or with the solar equator. The ecliptic at the time of totality is only inclined a few degrees to the vertical.

The observations of the "shadow-bands" is one of some interest, and as it only requires a white surface and a few light rods, a large number of observers should be forthcoming.

It must be remembered that the bands are usually very faint, and have to be definitely looked for. A white surface must be prepared to receive them; either a white sheet, which may be fastened down to the ground, or set up vertically on an upright frame, or a whitened wall. The surface should be marked with two straight black lines, one foot apart, that the intervals apart of

* See diagram at page 119 for Eclipse as visible in England.

the bands may be correctly judged. A rod should be placed to mark the direction of the bands themselves, as seen at the beginning of totality; and another to mark their direction of motion; another pair being used for a similar purpose for the bands seen at the close of totality; and after totality is over the most careful determinations must be made of the directions of the rods, and of the position of the sheet or wall. The following questions drawn up by Mr. E. W. Johnson for the assistance of the Members of the British Astronomical Association should be answered.

Questions.

1. How long before totality did the bands appear?
2. What number of bands were visible, say, in 10 seconds?
3. What was the direction of motion?
4. Where they inclined to the direction of motion?
5. What was the direction and force of the wind?
6. Did they come uniformly, or in batches?
7. What was their speed?
8. What was the width of the bands?
9. What was the distance apart of the bands?
10. Were they very faint, or clearly defined?
11. Was their direction after totality the same as before?
12. How long after were they visible?
13. Did you see any bands during totality?

The subject of shadow-bands leads naturally to meteorological work, for there is no doubt that the direction of the wind affects the direction of the motion of the bands. The meteorological observer should therefore provide himself with some form of vane and some means of ascertaining the force and speed of the wind. The wet and dry bulb thermometers would seem to be the next most important instruments to take, that the change in temperature and in saturation of the air might be marked. The barometer would come in the third place. It is of course desirable that observations should be made at regular intervals for some days both preceding and following the eclipse, especially at the same hour of the day as that when the eclipse takes place.

Those who find themselves about to witness the eclipse yet without any instruments or any preparations for observing should not let it pass without some record. They should note the appearance of the sweep of the shadow over the country as it comes and as it goes; the colours of sky, land and sea should also be noted, the sky being divided into three regions—namely, overhead, at sunlight, and near horizon.

Photographic cameras come very close to a definition of a telescope, and hence should be excluded from the scope of the present paper. Yet as in all probability there are some hundreds of possessors of cameras for every one who possesses an astronomical telescope, it is perhaps not superfluous to remind photographers that a very large field is open to them. Cameras with a focal length of two feet and upwards may be profitably used upon the corona itself. In this case the camera should be firmly fixed and exposures not exceeding half a second should be given. If the focal length be not more than 15 times the aperture, this with an extra rapid plate will probably be found quite sufficient. For shorter focal lengths shorter exposures or slower plates may be used.

Hand cameras may be profitably employed for photographing the landscape during the approach and recession of the shadow. A series of photographs taken at five minute intervals with a uniform speed of shutter, such as Miss Bacon took at Buxar in India, would give a very interesting and certainly very pretty record of the increase in the darkness as the eclipse comes on.

Finally, a valuable record of the total light of the eclipse can be obtained by exposing a plate in a printing frame to the light of the corona during totality. Portions of the plate can be exposed for different lengths of time or the plate itself may be placed under some form of sensitometer. Further information would be obtained by using as well different coloured screens in connection with plates of various coloured sensitiveness.

A PHOTOGRAPHIC SEARCH FOR AN INTERMERCURIAL PLANET.

It has not been, in general, the policy of the Harvard College Observatory to send expeditions to observe total eclipses of the Sun. First, since in the case of cloudy weather, no return is obtained for the expenditure of a sum of money which is often large. Secondly, if clear, the results in many cases are only a series of pictures of the corona and protuberances which add but little to our knowledge of them. Therefore, when officers of this Observatory have observed eclipses, it has generally been largely at their own expense. When, however, a new problem presents itself some aid is rendered from the funds of the Observatory, in the construction of instruments and for similar expenses. The following plan for observing the Eclipse of May 28th, 1900, has been prepared by Professor W. H. Pickering:—

It is a fact capable of demonstration, that the faintness of a star that may be photographed with a given instrument, against a bright background of sky depends, within certain limits, directly on the length of the focus of the lens, and is independent of its aperture.

In the Harvard Observatory Annals, Vol. XVIII., p. 104, it was shown that if the place in which to look for the Pole Star is known, that three minutes after it first becomes visible to the naked eye in the evening, the light of the sky in its immediate vicinity is of about the same photographic intensity as that of the sky surrounding the Sun at the time of a total solar eclipse.

Starting with these two fundamental facts, a series of experiments has been undertaken with a photographic lens having an aperture of 3 inches, and a focal length of 11 feet 4 inches. The curves adopted were those employed in an ordinary landscape lens, and it was found that the field was large enough to cover nine 8×10 photographic plates arranged in three rows of three each. This result was only obtained, however, by attaching the plates to the interior of a concave surface of double curvature, and thus obtaining a curved field.

By giving an exposure of one minute in the region of the Pole, with this instrument, three minutes after the Pole Star first became visible, it was found that the light of the sky was sufficient to darken the plate appreciably, but not so much as to prevent stars of the eighth magnitude appearing with sufficient intensity to be found by a careful search, in the larger part of the field of view.

Three similar lenses have now been ordered, and the four will be placed upon one mounting, in such a manner as to photograph a region extending for sixteen degrees on either side of the Sun, and having a breadth of ten degrees throughout its length. Throughout nineteen

degrees of its length every portion of the region will appear upon two separate plates.

The satellites of Mars, Jupiter, and Saturn all revolve very nearly in the equatorial planes of their primaries, and in the same manner Mercury revolves very nearly in the equatorial plane of the Sun, which is inclined about seven degrees to the plane of the ecliptic. It is, therefore, reasonable to suppose that bodies still nearer to the Sun would revolve in the same plane. It so happens that the Earth passes through this plane about one week after the date of the solar eclipse of next May, so that there is a strong probability that if an intermercurial planet exists, it will appear somewhere upon the narrow line forming the projection of this plane upon the celestial sphere. It will be seen, therefore, that the date of this eclipse is especially favourable for the proposed search.

We have very good evidence, from the visual observations hitherto made, that no intermercurial planet brighter than the third or fourth magnitude exists. We possess no evidence whatever for or against the existence of fainter bodies in this region having sufficient size to be properly called planets. We are reasonably certain that the immediate vicinity of the Sun is filled with countless bodies of such size as to be properly described as meteors.

If we assume that at its average brightness, Mercury is of the first magnitude, and that the albedo of an intermercurial planet is the same as that of Mercury, we shall find that at the distance of Mercury from the Sun, a body of the eighth magnitude would be 120 miles in diameter. If its distance from the Sun was but one half as great, its diameter would be 60 miles, and if but one quarter as great, or 9,000,000 miles, it would be 30 miles in diameter. Judging by the analogous case of Jupiter, the existence of such a small planet is quite possible.

Should such a body exist, and should it appear upon the plates, which it is proposed to expose somewhere in the State of Alabama, we should still be entirely at a loss to compute the orbit, or to determine the distance of the body from the Sun. If, however, other photographs of it should be obtained with a similar apparatus, in Spain or Algeria, we should then be enabled to compute an approximate orbit, based upon the assumption that it moved in a circular path. It might then be found again at the following eclipse, which occurs a year later, and a more accurate elliptical orbit could be computed for it. While it is desirable that the duplicate apparatus should be also furnished with four lenses, this is not necessary, and in case the planet should be found upon our plates, two lenses, one photographing the region on each side of the Sun, would be all that would be necessary to independently make the discovery, and furnish the elements necessary to compute the circular orbit. It is in the hope of inducing some European observer to supply himself with this apparatus that the present article has been written.

The foregoing plan appears to be of sufficient importance to justify aid from the Observatory. Preparations have, therefore, been made to give it a careful trial It is hoped that this early publication may permit similar observations to be made at a second station sufficiently distant to reduce the danger of failure from clouds, and if an intermercurial planet should be found, to furnish an approximate determination of the form of its orbit.

EDWARD C. PICKERING.

Harvard College Observatory,
February 13th, 1900.

THE PHOTOGRAPHY OF CLOUDS.

By EUGENE ANTONIADI, F.R.A.S.

(*Continued from page* 81.)

SOME additional references to exposure may be given in the data accompanying the annexed photographs :—

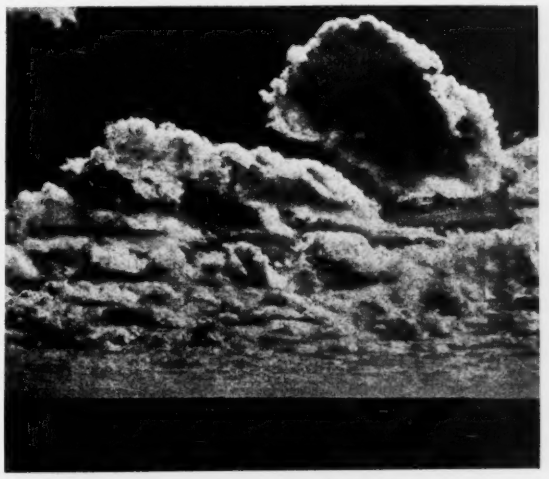


FIG. 1.—Cumuli forecasting fine weather, 1899, August, 29d. 9h. 45m. a.m., local time.

Subjoined Plate, Fig. 1.—Cirro-cumulus, following and forecasting wet weather. Photograph taken with the

FIG. 3.—Photograph of the primary and secondary Rainbows, taken at Juvisy on 1899, September, 28d. 5h. 3m., local time.

1·04-inch object glass, whose focal length is 5·12 inches. Yellow screen of moderate intensity, on account of the deep blue sky. Stop=$\frac{f}{11}$. Exposure=1 full second.

Plate, Fig. 2.—Nimbus covering the setting sun, whose rays gild the upper edge* of the cloud bank, during rainy weather. Showers are actually seen falling from the cloud on the horizon. Same object glass. No yellow screen, owing to the absolute lack of blue. Stop=$\frac{f}{32}$. Exposure=$\frac{1}{10}$ second.

Figure 1 (text).—Peaceful cumuli during warm weather. Same glass. Faint yellow screen. Stop=$\frac{f}{16}$. Exposure =$\frac{5}{8}$ second, in strong sunshine.

Figure 2.—Sunset behind ragged clouds. Same glass. No screen at all. Stop=$\frac{f}{22}$. Exposure=$\frac{1}{15}$ second.

Figure 3.—Rainbow, with a nearly horizontal sun.

Fig. 2.—Sunset effect, 1899, September, 24d. 5h. 25m., local time.

The secondary bow is very marked on the negative; but there are no supernumeraries. Same glass. No yellow screen. Stop=whole aperture. Exposure=$\frac{1}{25}$ second. *Short exposures are particularly effective on rainbows.*

The excellent isochromatic plates of Messrs. A. Lumière et ses Fils, of Lyons, have been invariably used here by M. Mathieu and the writer in their attempts at cloud photography.

The development of cloud plates is done in the ordinary fashion, though plates sensible to the red should be developed with a very weak red light only, in order to avoid fogging. The solution should, of course, not be too strong, while haste is particularly nugatory. A slow, methodical development always yields good results. At Juvisy, pyrogallic acid is used in preference to other substances. An enfeebled old solution, intensified when necessary, is, moreover, preferable to a new one. Finally, the question of the moment of stopping the development is one which experience only can decide.

* These golden fringes, due to the illumination of the cloud from behind, are also visible round cumuli at night during lightning flashes. In a paper published however, in 1899, in the "Bulletin de la Société Astronomique," a M. Touchet, quite misunderstanding the nature of the occurrence, introduced the unscientific notion of "lightning ribbons running along the clouds' edges."

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

IS THE STELLAR UNIVERSE FINITE?

TO THE EDITORS OF KNOWLEDGE.

Sirs,—I cannot enter into this discussion, but may I suggest, as a point which appears to me to have been overlooked, that the Ether as a transmitting medium for light is limited in extent, and belongs specially to a cluster of stars of which our solar system is a part, and that it thins out at a finite distance from that cluster (in the same way that our atmosphere thins out at a distance from the earth) until it is incapable of transmitting light. In that case, the Stellar Universe might be infinite, but there would be a "rapid decrease in the luminosity of the stars" at a great distance from us, owing to the decreased transmitting power of the ether; and though the stars were just as numerous beyond the ether, there would be nothing to transmit their light.

Geo. Phelps.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Mr. Anderson says that "individually they" (the brighter and fainter stars) "do not lose the same

XUM

XUM

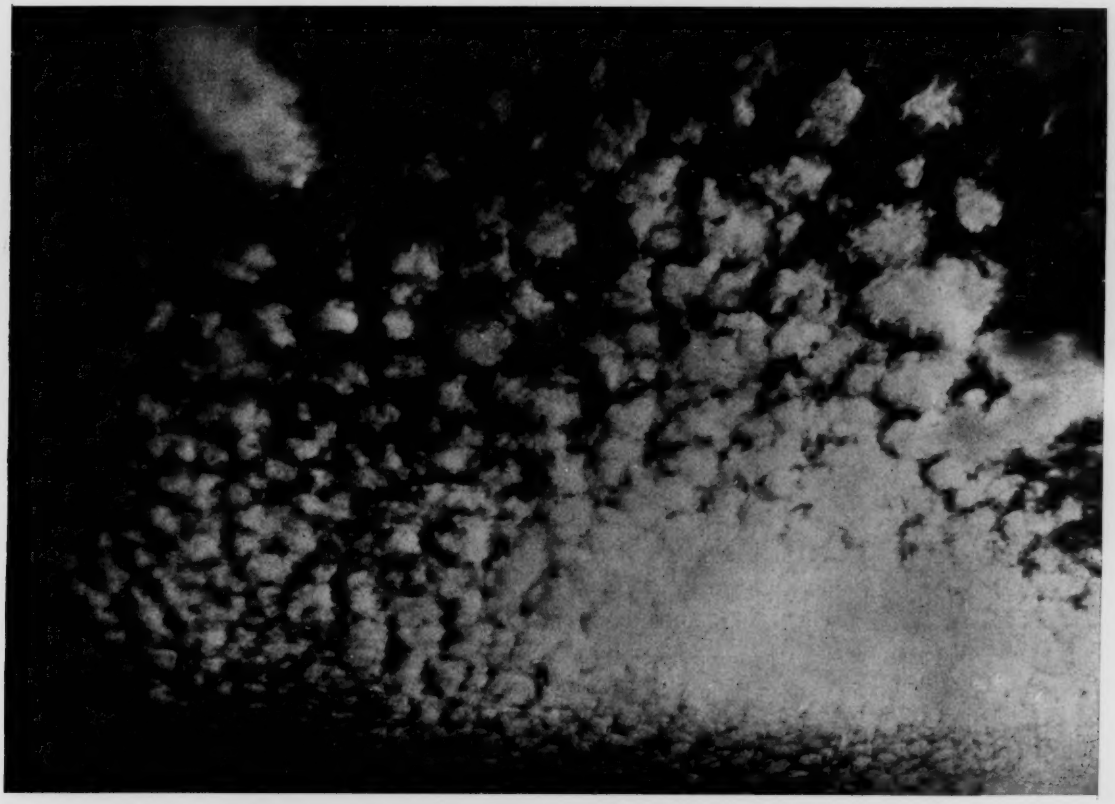


FIG. 1.—Cirro-cumulus, 1899, September, 25d. 2h. 25m., Mean Local Time.

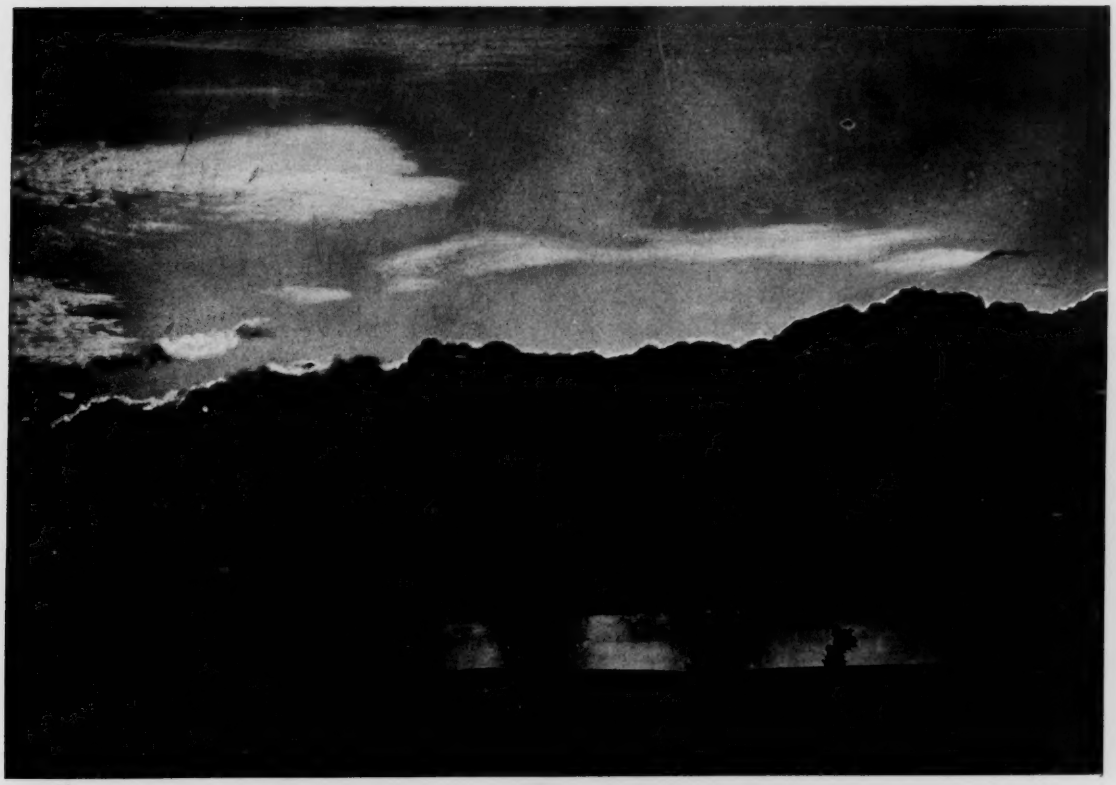


FIG. 2.—Rain-Cloud, during Showery Weather, 1899, July, 1d. 6h. 55m. p.m., Local Time.

CLOUD PHOTOGRAPHS TAKEN AT JUVISY.

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proportion of their total light" by atmospheric absorption and similar causes. May I ask by what experiments or observations this is proved? All the photometries with which I am acquainted proceed on the opposite principle. In none of them is a different estimate made for atmospheric absorption in the case of bright and faint stars. Prof. Pritchard's photometer depends on the thickness of a plate of neutral-tinted glass which is required to extinguish the light of the star. It would fail if there was a more rapid (proportional) extinction in the case of faint stars than of bright ones.

When a star is near the limit of vision a small reduction in its light renders it imperceptible as a separate object. A field-glass, however, will suffice to discover it. With a further reduction in the light a telescope would be required, and we should afterwards have to discard our first telescope and use a more powerful one. But can anyone suppose that in these cases it produces no effect at all unless it is separately visible? Mr. Anderson disavows this argument, however, and, therefore, I need not discuss it.

Considering the great number of different places at which observations are now made, and the fact that star-gauges are usually made at the most favourable time for observation, I can hardly believe that there are any stars brighter than say the 12th magnitude which have remained undiscovered because they were always too near the horizon to be visible with a telescope calculated to show all stars down to the 14th magnitude. (Of course the visibility or invisibility of faint stars depends entirely on the instrument employed.)

Supposing that with our present instruments no star below the 10th magnitude can escape us, why should we not trust our star-gauges up to that magnitude? And why should we not use the general luminosity of the sky as an indication of the distribution of still fainter stars?

I am not writing in favour of either a finite or an infinite Universe. I only desire to call the attention of astronomers to one of the unsolved problems which the science presents; and I am surprised to find so many writers both in your columns and elsewhere dealing with it on popular or metaphysical grounds rather than as a scientific problem.

W. H. S. MONCK.

P.S.—In my last letter "α Centauri" was printed "and Centauri." The reader will no doubt have seen the mistake.

[I must express my full agreement with the concluding words of Mr. Monck's letter. The question of the shape and extent of the general sidereal universe as it presents itself to us seems to me an interesting and important one, and any mode of enquiry which would enable us for instance to form an estimate of the mean distance of the Galaxy and of its mean depth should I think be welcomed and carefully examined. But the general question "Is the Stellar Universe finite?" becomes at once not a physical but a metaphysical enquiry, and hence leaves the domain of astronomy, and except as a purely mental exercise I see no value in it. How easily even the keenest and most trained minds may go astray on the subject may be learned from Prof. Newcomb's paper in the March number of the "Windsor Magazine." He writes "It can be shown mathematically that an infinitely extended system of stars would fill the heavens with a blaze of light like that of the noonday sun." There is a tacit assumption here that the stars are on the average uniformly distributed in space, an assumption which for nearly a century astronomers have known to be untrue.

I must ask, therefore, that correspondents in future will leave the general and metaphysical question entirely alone, and confine themselves to the question of the actual distribution of the known stars.

[E. WALTER MAUNDER.]

WIRELESS-TELEGRAPH RECEIVER.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—One evening last summer I was using the receiver in the ordinary way in connection with a Morse printing machine; it was a dull evening with a good deal of thunder about; and I noticed that a dot was printed at every flash of lightning. Of course that would be expected, since the receiver was not protected in any way, but when I joined up a small galvanometer in place of the Morse machine, I found greatly to my surprise that the needle of the galvanometer was affected by the lightning through the coherer, an instant before the flash was visible to me. I noticed it several times. The only explanation I can think of is that the electric discharge caused by the lightning has a quicker effect upon the coherer than upon the human brain or nerves.

NORMAN ROBINSON.

[The really important conclusion to which your correspondent's observations seem to point is this:—The galvanometer used was sensitive to something which occurred immediately before the lightning flash was made manifest, as regards which, it seems clear that the "recorder" took no note of it. Two questions are at once suggested: What was this something, and, was the galvanometer in no way affected by the immediately succeeding, and expected, effect which caused the Morse to "dot"? Stating the second question in another way, "Did the needle give but one kick?"

Again, as regards the producer of the effect alluded to, apparently it was Hertzian, Electro-magnetic, or Electro-static. Possibly it was forces of these three natures acting together, or any two of them in conjunction—if not a single one. Unfortunately Mr. Robinson gives us no details as to the windings (and self induction co-efficients) of the instruments which he used—and interchanged. However, the subject is one of great interest, and it seems that no one has hitherto wandered into the path indicated.—HOWARD B. LITTLE.]

A CLOUD OF DRIED BEECH LEAVES.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—The following may be interesting, not only as an unusual occurrence, but as bearing on the question of aerial transportation of seeds, etc.

At about four o'clock on the afternoon of Sunday last (April 1st), my attention was arrested by the fall of numbers of dried beech leaves. On looking up I found that the leaves were passing in large numbers from east to west, and as high as the limit of vision. Many appeared to be mere specks, whose height and motion promised them a journey of some miles at least. The shower continued for perhaps twenty minutes. The fall was noticed by many persons here, who were unable to account for it, as there are no beech trees within two miles at nearest. Probably the leaves had been raised by a whirlwind, and at a very considerable distance east of this neighbourhood.

A friend, who was some three miles east of my station, witnessed the phenomenon, and states that by the aid of a field-glass he could see leaves still higher than those

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visible to the naked eye, and yet felt that he had not even then reached the highest.

The morning had been clear and bright, but at the time of this occurrence the east sky was covered with a thick thundery-looking haze. There was no surface wind. Barometer steady at about 30.2 inches.

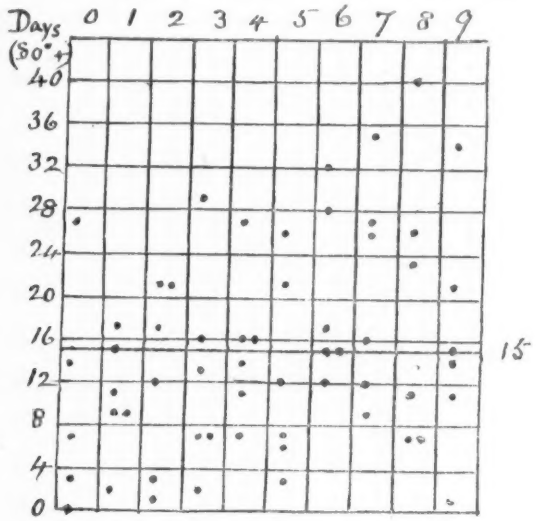
Wallingford, Berks. T. H. Astbury.

LONDON SUMMERS.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—A short time ago I offered some evidence for a connexion between our summers and the sunspot cycle of about eleven years. While still of opinion that much may be said for this view, it has of late seemed to me worth consideration whether a shorter period, say of about ten years, might not give a better account of the facts.

Perhaps you will allow me to supplement that article with a diagram in which the fifty-nine Greenwich summers, 1841-99, are grouped according to the number in which the year ends (years ending in 0, in 1, in 2, &c. and so on up to 9). Each dot represents a summer



Distribution of 59 Summers (Greenwich) in 10 Columns.

season, and shows by its position how many days with temperature 80° or more it had. The average is 15 (represented by a line).

(As the series begins with 1841, the column 0 is one dot short.)

One is struck, I think, by the greater coolness, generally, in the earlier part, and the general rise in position of the dots as the decade advances to the 6-8 groups.

The averages of the columns come out as follows:—

0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
10·2	10·5	12·5	12·3	15·2	12·5	19·8	20·8	15·7	16·0

Thus the summers of years ending in 7 have had, on an average, more than twice as many of those hot days as the summers of years ending in 0.

Four of the first five values are below the general average; four of the last five values above it.

From this point of view, then (and it is a purely empirical one), cool summers seem to be more probable than hot ones in the immediate future, and we should hardly expect any extremely hot ones. It remains to be seen whether the next sixty summers will have the same general distribution as those now considered.

Other facts pointing in the same direction might, I think, be given, but I will not here enlarge on the subject. Alex. B. MacDowall.

Ornithological Notes.—In the absence from England of Mr. Harry F. Witherby, the Ornithological Notes are held over.

Obituary.

Science loses one of her chief ornaments by the death of Professor St. George Mivart, F.R.S., who expired on the 1st April, 1900. Born in November, 1827, he was educated at Clapham Grammar School, Harrow, and King's College, London. In 1851 he was called to the Bar, but, attracted by scientific studies, he became lecturer at St. Mary's Hospital Medical School in 1862. Dr. Mivart was at variance with Darwin as regards "natural selection" and evolution as applied to the human intellect, and in the early seventies engaged much in controversy on these subjects, always with great literary skill, however his opinions might differ from those of his opponents. In 1867 he was elected a Fellow of the Royal Society, and in 1869 he became Vice-President of the Zoological Society. Dr. Mivart was an accomplished lecturer, well known in that capacity, not only in London but throughout the country. Among his works may be mentioned "The Genesis of Species," 1871; "Lessons in Elementary Anatomy," 1872; "Man and Apes," 1873; "Lessons from Nature" and "Contemporary Evolution," 1876; "The Cat," 1881; "Nature and Thought," 1883; "The Origin of Human Reason," 1889. Dr. Mivart's last days were occupied by a controversy with the heads of his church. The correspondence in the "Times" of January 27 and 29, 1900, indicated that for some years a conflict had been steadily growing in his mind between the force of private judgment and the necessity of submission to authority.

Professor John Henry Pepper, who died last month in his 80th year, attained fame by means of the "ghost illusion" which in the sixties was very much in vogue at the theatres. At the Polytechnic in Regent Street the exhibition succeeded both scientifically and as a commercial enterprise. Prof. Pepper was the author of several popular science books, and these, together with his skill as a lecturer, did much to attract public attention to science subjects. "Pepper's Ghost" is said to have been suggested to the inventor by observing the images of his fellow passengers while riding home in a train late at night, the glass windows reflecting their faces on the "darkness" outside.

Notices of Books.

"Photographs of Stars, Star-Clusters, and Nebulæ, together with Records of Results obtained in the Pursuit of Celestial Photography." By Isaac Roberts, D.Sc., F.R.S. Volume II. (London: Knowledge Office, 326, High Holborn, W.C.) 1899. Price 30s. It is a very difficult matter for astronomers living at the present day to fully estimate the value of Dr. Isaac Roberts' series of stellar and nebular photographs of which the second volume has just been issued. That they are very beautiful photographs of beautiful and wonderful objects is clear; it is patent to the most casual glance. That they will amply repay the study of Dr. Dreyer (in whose hands we believe that copies have been placed for examination) will soon also be evident. But it is only a few of their secrets that will be disclosed by the study of some months or years, and it will be for future generations to fully understand the value of the work which Dr. Roberts has undertaken. Dr. Roberts has himself foreseen this, and has felt it necessary that the photographs should be printed in permanent ink, for not only are the original glass negatives liable to be lost by accidental breakage, but he finds that, "after the lapse of a limited number of years the gelatine films will become discoloured, the images will fade, and the faint stars and the faint

nebulosities will entirely disappear from view." This is a factor that should certainly be borne in mind by the directors of those observatories which are taking part in the work of international charting, for though the cost of reproduction of all the plates on paper print with permanent ink may be considerable, it is insignificant when compared with the cost of procuring the original negatives which may through lapse of time become valueless. Though we may be assured that in these photographs lie hidden the solution of many problems that have not been even stated as yet, the mere superficial investigation of one of these photographs seems to indicate many avenues for investigation. Four or five hours were spent in the study of one selected almost at random, and a few of the forms and configurations depicted in it were followed out. Cluster H VI. 5 Orionis which is reproduced in Plate 2 is by no means one of the most striking photographs in the volume. It is no huge cluster, and no trace of nebulosity could be discovered. To the astronomical eye, however, its star images are objects of extreme beauty, being very small and perfectly round, the fainter stars looking like needle points of white on the dark background. In the s.f. corner of the Plate there is one of the most perfect spiral of stars that we have ever seen. No vestige of nebulosity is to be seen stretching in the spaces between the stars which curve through seven distinct widening convolutions round the large star which is evidently the central condensation of the original spiral nebula. The stars vary greatly in magnitude, large and small being intertwined in the convolutions without apparent law. From its appearance the stellar spiral is a left-handed planar not a helical one, and its plane is not far from being perpendicular to the line of sight. The whole is like the sevenfold coil of a huge serpent covering some 20′ of arc in the sky. In the centre of the plate is another spiral of stars of a different species, and not of so distinct and perfect a nature. Here can be dimly made out a series of spirals which radiate from a common centre like the feelers of the cuttle fish. Following this central cluster by about 16′ to 21′ are two other clusters which Dr. Roberts says are suggestive of a spiral origin. A close examination indicates that these two clusters are not distinct but form part of the same helix of stars (which is a very perfect one). The apparent clustering seems due to the oblique presentation of the helix, which might be represented by three turns of a corkscrew. In this spiral the stars do not appear to present so great a range of magnitude as in the other two described. These three do not by any means exhaust the spiral forms which are to be found in this very wonderful photograph. In every region of the Plate are to be found spiral systems under some type or presentation. We heartily congratulate and thank Dr. Roberts for his issue of these beautiful and valuable photographs.

"Animals in Motion." An Electrophotographic Investigation of Consecutive Phases of Animal Progressive Movements. By Eadweard Muybridge. (Chapman and Hall.) 20s. net. Of all the results which have followed the introduction some quarter of a century ago of photographic methods into scientific research, the knowledge of animal locomotion which Mr. Muybridge has given to the world is certainly not the least important and interesting. Like many other investigators, Mr. Muybridge was put upon the track of his future elaborate experiments by a very simple incident. As he tells the reader in his preface, he was in the spring of 1872 directing the photographic surveys of the United States Government on the Pacific Coast, and being in San Francisco he took part in a controversy, the principal subject of which was the possibility of a horse while trotting—even at the height of its speed—having all four of his feet, during any portion of his stride, simultaneously free from contact with the ground. Mr. Muybridge resolved to attempt the settlement of the question, and though the days of the rapid dry photographic process had not yet come, he was soon at work with wet collodion plates. He commenced his investigation on the race-track at Sacramento in May of the same year, and in a few days made several negatives of a horse trotting literally in front of his camera at varying speeds; some of the resulting photographs exhibited the horse with all four of his feet clearly lifted, at the same time, above the surface of the ground. The next step was to obtain a series of photographs in rapid succession at properly regulated intervals of time, or distance, so as to discover the true explanation of animal movements. After designing special apparatus and utilising the leisure hours of a busy official career, Mr. Muybridge was able in 1878 to deposit at Washington Congress Library sheets of photographs illustrating consecutive phases of one complete stride of a horse, while walking, trotting, galloping, and so on. Then came the construction of the zoöpraxiscope, an instrument for synthesising the actual image from these separate impressions. The discovery of celluloid ribbons, which made it possible to obtain a larger number of successive phases of motion, led the way to Edison's kinetoscope. But all these successes Mr. Muybridge regards as preliminary work to the production of his masterpiece of 1887, known as "Animal Locomotion," and containing more than 20,000 figures of moving men, women, children, beasts, and birds, in 781 photo-engravings, bound in eleven folio volumes. The possibility of taking the hundred thousand plates which were used in the preparation of this monumental work, and of publishing it, was due to the public-spirited action of the University of Pennsylvania, which undertook the expense. The volume under consideration comprises a selection of the most important plates contained in the larger volume on a reduced scale, and should be in the hands of every student of science and art, since the plates furnish a trustworthy guide to the laws which control animal movements.

"A Book of Whales." By F. E. Beddard. Progressive Science Series. (Murray.) 1900. Illustrated. 6s. The huge bodily size of its more typical members, the few opportunities that landsmen have of seeing them, coupled with the fact that, in spite of their generally fish-like form, they are warm-blooded animals, surrounds the group of Whales, or cetaceans, with a halo of mystery and fascination which cannot fail to attract general interest. It is, therefore, most satisfactory to have a popular and succinct account of the group from a writer who has evidently worked hard at his subject and brought together almost all that is worth knowing concerning the structure and mode of life of these strange creatures. Taken as a whole, it may be said that Mr. Beddard's treatise is all that can be desired, and that it is likely to remain for a long time the standard popular work on the subject. To a certain extent it is more than this, for it enters on the consideration of many technical details—notably as regards the number of species, and the affinities of the various genera. Indeed, there may be a question whether the author has in all cases descended to the level of his readers, the use of terms like "thoracic musculature" when "muscles of the chest" would have served the purpose better, being calculated to mystify the uninitiated. Especially is this noticeable in the section devoted to osteology, where the ordinary reader is likely to be puzzled as to the exact meaning of terms like "acromion" and "coracoid process." And since figures of many bones are given, the difficulty could have been so easily avoided by the addition of descriptive letters. Confusion is also made by figuring in Plate IV. tympanic bones of the Right Whale and the Rorqual which belong to opposite sides. If we were disposed to be critical we could point out a good many typographical and grammatical blemishes; but in regard to errors of this description we will be content with asking our readers to compare the figure of Balæna australis facing page 22 with the cast in the Natural History Museum, from which it is taken, when we venture to affirm that a surprise will await them.

Among the more interesting features of Whales are the numerous "vestigial" structures to be met with, such as the functionless teeth of fœtal Rorquals, and the bony plates on certain Porpoises. That Cetaceans had toothed ancestors, everyone was prepared to admit, but that their progenitors should have been mail-clad animals is indeed a "staggerer." But it is very difficult to come to any other conclusion. And this leads to a puzzle, for the only mammals that are known to possess such an armour are the Armadillos and certain other Edentates, which are in no sense ancestral Cetaceans. Here, we regret to say, the author is not quite so clear as is desirable. While of opinion that both the Whalebone and the Toothed Whales have a common ancestry (p. 106), he seems undecided whether to regard such ancestry as connected with the Sirenia or the Ungulata. But if a dermal armour were present, it is quite certain that such ancestry had nothing to do with the sea-cows, while it is difficult to see where the ungulate connection could have come in. Apparently Mr. Beddard will have nothing to do with a carnivorous ancestry for his favourites; although if this view were accepted the armour difficulty remains in full force.

An important feature in the work is the attention paid to fossil forms, and although the reference to these is for the most part satisfactory, exception may be taken by some to the statement that Whalebone Whales do not antedate the Miocene. Being in a charitable mood, we will assume that the statement on page 20 as to the derivation of Whales from Reptiles is a lapsus calami; but we must take exception to the one on page 220—that the Sabre-toothed Tigers were hindered by the conformation of their tusks from opening their mouths to the fullest extent!

In some parts, too, the author appears unnecessarily sceptical, as for instance when (p. 199) he refuses to credit the statement that the Sperm Whale drops its lower jaw when feeding. Mr. Bullen's observations in the "Cruise of the 'Cachalot'" ought

rather to have raised the question whether this animal can ever close its mouth when in the normal position. In refusing credence to the stories of Thresher Sharks attacking Whales, the author may have more justification on his side. In reference to minor errors, it may be added that the late Sir William Flower, and not Mr. Lydekker, is responsible for the statement that the Greenland Whale has only twelve ribs. It may also be mentioned that the names Pontoporia, Neomeris and Ziphius, used by Mr. Beddard, are all preoccupied.

"British Dragon-Flies." By W. J. Lucas, B.A. (L. Upcott Gill.) 31s. 6d. Mr. Lucas has accomplished a very useful piece of work. Not only has he brought together into one volume information which hitherto was only to be found scattered through the journals of scientific societies and periodicals concerned with natural history, but he has by means of his handsome book drawn attention to a group of the Neuroptera which has been neglected in this country. Many reasons have conspired to bring about this neglect. The popular, though unfounded, dread of dragon-flies has had something to do with it. The comparative scarcity of the Odonata (the name under which the dragon-flies are known to the entomologist) is another cause tending to bring about the same result, while the obscure manner in which the early stages of these insects are passed has not helped their popularity with the ordinary collector. But dragon-flies will repay a careful study. The complete cycle of changes constituting their life-history is somewhat prolonged, it is true, but these animals are fascinating always, and indirectly of great use in the world. They are carnivorous and show no compunctions as to cannibalism. Of their beauty it is unnecessary to say anything; few people have failed to notice their graceful movements, rapid flight, and marvellous play of colours. Widespread as is the belief in their stinging powers, and accentuated as this superstition is as evidenced by their common name of "Horse-stingers," yet in reality they have no sting, and the very worst they can do is to inflict a slight bite which is almost painless. The insect's peculiar habit of curling the tip of its abdomen seems to be entirely responsible for the dread in which the rustic holds it. The volume is provided with twenty-seven beautifully coloured plates. The drawings of the larger species are given of the natural size, those of the smaller varieties being suitably magnified.

"Malay Magic; being an Introduction to the Folk-lore and Popular Religion of the Malay Peninsula." By W. W. Skeat. With a Preface by C. O. Blagden. 1900. (Macmillan.) 21s. net. It has been objected to the study of "Folk-lore" that it deals with fancies and myths rather than with serious "facts," and that it is therefore unworthy the attention of sober-minded men. But it may be hoped that such objections are now entertained only by the few; the majority admitting that from a psychological point of view such studies cannot but lay claim to a large share of interest, while occasionally they may be of great practical importance. As stated in the preface, "there can be no doubt that an understanding of the ideas and modes of thought of an alien people in a relatively low stage of civilisation facilitates very considerably the task of governing them." Every Anglo-Indian can recall instances where gross mistakes have been made by Government officials from want of touch with the feelings and prejudices of the people under their charge; and since the greater portion of the Malay Peninsula is now under British control, this alone affords a sufficient raison d'etre for the work before us.

The author appears to have carried out a very laborious task with conscientiousness and thoroughness, and has at the same time succeeded in producing a highly entertaining and instructive volume. Among the various subjects treated of, we find legends connected with the creation of man and the world, magical rites and magicians, spirits and demons, the various ceremonies connected with the chief epochs of human existence, together with dances, sports, games, theatrical exhibitions, and war and weapons. A series of photographic reproductions illustrate some of the more interesting of the objects and ceremonies described.

On this occasion we may confine our attention to a few of the myths connected with animals. Naturally, the elephant and the tiger loom large in Malay myth; and legends of ghost-elephants ("gajah kramat") and ghost-tigers ("rimau kramat") take the place of the "wehr-wolf" of European tradition. "Far away in the jungle," runs the myth, "the tiger-folk (no less than the elephants) have a town of their own, where they live in houses, and act in every respect like human beings. In the town referred to their house-posts are made of the heart of the tree-nettle, and their roofs thatched with human hair, ... and there they live quietly enough until one of their periodical attacks of fierceness comes on and causes them to break bounds and range the forest for their chosen prey." Elsewhere, we find the origin of the tiger's stripes attributed to the chastisement inflicted on an unruly boy, who thereupon took the form of the great cat. The existence of the ghost-tiger, who is supposed to be invulnerable and to have one foot smaller than the rest, is a veritable reality to the Malays, who know the myth to be true, and act accordingly. When a wounded tiger escapes, it is believed to cure itself by eating a particular plant; and on the death of one of these marauders a special ceremony is held in honour of the body, which is propped up on all fours as if still alive, with the mouth kept wide open by means of a stick supporting the upper jaw. The ceremony, says the author, "was evidently regarded as a sort of 'reception' given by the people of the village to a live and powerful war-chief, a champion who had come to pay them a visit, the dancing and fencing which takes place on such occasions being intended for his entertainment."

Many other equally interesting extracts might be made did space permit, but we must refer the reader to the work itself, where he will scarcely fail to find much matter alike for amusement and for reflection.

"The Railways of England." Fifth Edition. By W. M. Ackworth. (Murray.) Illustrated. 10s. 6d. We are pleased to see a reprint of this useful work. Among the most wonderful innovations of the nineteenth century must be included that great spider's web of rails, spreading out in all directions over the land; and anyone who has not already attained a comprehensive acquaintance with our chief highways of communication will do well to secure a copy of Mr. Ackworth's book. Here some idea of the enormous strides effected by man's ingenuity since the year 1830, when the first public railway was opened in Lancashire, may be formed. Even during the past decade it is surprising to note what rapid transitions have taken place, rolling stock becoming to a great extent antiquated in so brief a period. The present edition has been put in touch with the latest developments, although the main features remain the same as in the first edition published ten years ago. All the leading railways are separately described, and, wherever possible, illustrations accompany the text. The picture of Waterloo Station as it appeared in 1848 forms an agreeable contrast with the present imposing structure; also the facsimile of a handbill announcing a four-days' journey to York in 1706 by means of a stage coach, and the same journey accomplished in three and a half hours in 1888 by railway, illustrate in a telling fashion the advantages of modern modes of travelling. We may add that the book is by no means technical in character, but, on the contrary, it is written in a clear and luminous style.

"Recent and Coming Eclipses." By Sir Norman Lockyer, K.C.B., F.R.S. Second Edition. Containing an account of the observations made at Viziadrug, India, in 1898, and of the conditions of the eclipses visible in 1900, 1901, and 1903. (London: Macmillan & Co., Limited.) 1900. Price 6s. net. The issue of the second edition of Sir Norman Lockyer's eclipse book is timely, just before the observers start on their several expeditions to see the eclipse of May 28th, 1900. In view of a third edition before the Sumatra eclipse, we would like to relate the comment of a doctor in India who read chapter II. on "Eclipse Work for Amateurs" before the 1898 eclipse with interest, and, after it, with sorrow tempered by indignation. "I should like to make Sir Norman Lockyer sit down to a microscope and draw in two minutes the essential features of a pathological specimen of liver unstained that he has never seen before. Then he might understand the feelings of a doctor who was lured into trying too many observations of the eclipse." Sir Norman Lockyer is certainly a past master in eclipse observation, but there is a serious defect in all his books which is also painfully apparent in this, that he himself seems to be both centre and circumference of the only field of research about which he cares to write. The gibing little rhyme written of him a third of a century ago, that he

"Thought himself owner
Of half the corona,"

seems to express but a moiety of the truth to-day. The book is a record of much good work, admirably planned and skilfully executed, nor is there any other single astronomer who could present an equal record of eclipse work from his own personal experience. But from the undue concentration upon his own theories and research the book is distinctly inadequate as a history of recent eclipse work. His recognition of other workers is extremely meagre. Thus in the eclipse of 1898 no reference at all is made to the observing party at Talni, although the spectra there obtained by Mr. Evershed were, in some respects at least, unequalled by any obtained elsewhere. The book is got up in the style which we are accustomed to connect with Sir Norman's other publications; the paper and print are good; the illustrations of a very inferior class.

"Anatomical Diagrams for the Use of Art Students." By James M. Dunlop, A.R.C.A. (George Bell & Sons.) An admirable and much needed work. The principles of action from the artistic point of view are expressed with absolute clearness. We commend it heartily to art students.

"The Norwegian North Polar Expedition, 1893-1896. Scientific Results." Volume I. Edited by Fridtjof Nansen. (Longmans.) Illustrated. 40s. net.

PRELIMINARY NOTICE.

The publication of the memoirs relating to the now famous "Fram" expedition will be eagerly welcomed by the scientific world. The first volume, a handsome quarto, very finely illustrated, is before us; it is to be followed by four or five of the same character.

The present volume contains memoirs on "The Jurassic Fauna of Cape Flora," by Dr. Pompeckj; the fossil plants from Franz Josef Land, by Dr. A. G. Nathorst; an account of the birds collected by Mr. Collet and Dr. Nansen; and the crustacea, by Mr. G. O. Sars.

The second volume will in all probability be taken up with the astronomical and magnetic results of the expedition. The monograph on the Celanography of the Polar Regions by Dr. Nansen is expected to appear in the third volume, together with "The depths and submarine features of the North Polar Regions," by the same author. The whole work will be completed in the course of about two years.

Our countrymen will be gratified to learn that the work is published in the English language only, which is regarded by the Editor as the most international tongue.

BOOKS RECEIVED.

Illustrated Annual of Microscopy—1900. (Percy Lund.)

Open Access in Public Libraries Exposed. By Edw. Foskett. (Curtis & Beamish.) 3d.

Calendar of the Science and Art Department—1900. 8½d.

Official Proceedings of the International Commercial Congress. (Philadelphia Commercial Museum.)

The Theory and Practice of Interpolation. By Herbert L. Rice. (The Nichols Press, Lynn, Mass.)

The Humane Review. April, 1900. (Bell.) 1s.

Practical Physics—Descriptive Catalogue of Apparatus. (Griffin.)

Francis Mary Buss Schools—Jubilee Magazine. April, 1900.

A Surgical Operating Table for the Horse. By Jno. A. W. Dollar. (Douglas.) 2s. 6d.

The Reliquary and Illustrated Archæologist. April. (Bemrose.) 2s. 6d.

Inorganic Evolution. By Sir Norman Lockyer. (Macmillan.) 4s.

Sexual Dimorphism in the Animal Kingdom. By J. T. Cunningham. (Black.) Illustrated. 12s. 6d. net.

A Treatise on Zoology. Edited by E. Ray Lankester, F.R.S. Part III.—The Echinoderma. (Black.) Illustrated. 15s. net.

Micro-Organisms and Fermentation. Third Edition. By Alfred Jörgensen. (Macmillan.) 10s. net.

Mental Culture. By George A. Hight. (Dent.) 3s. 6d. net.

Man and His Ancestor. By Chas. Morris. (Macmillan.) 5s.

The Struggle for Empire. By Robt. W. Cole. (Elliot Stock.)

Lessons in Elementary Physiology. New Edition. By Thomas H. Huxley. (Macmillan.) Illustrated. 4s. 6d.

Wireless Telegraphy and Hertzian Waves. By S. R. Bottone. (Whittaker.) 3s.

The Concise English Dictionary. New Edition. By Chas. Annandale. (Blackie.) 3s. 6d.

Smithsonian Institution—The Secretary's Report for the year ending June 30th, 1899.

The Studio. April, 1900. 1s.

WIRELESS TELEGRAPHY.—II.

By G. W. DE TUNZELMANN, B.SC.

AFTER the digressions made in the last article I will now ask my readers to return to the main subject of the present series, Hertzian Telegraphy, viz., a system of telegraphic communication by means of electric disturbances set up in, and transmitted from place to place through, the ether. The general outline of the subject contained in the earlier portion of the article referred to sufficiently indicates the simplest and most logical order of development of the subject to be the study, in the first place, of the medium in which the disturbances are excited, secondly, an inquiry into the nature of these disturbances; and here so little is definitely known that I can do little more than set forth hypotheses which would more or less fully explain the observed phenomena and which probably have a more or less distant resemblance to the actual facts; and, finally, an account of the apparatus and methods which have been employed in the winning of such knowledge as we have so far obtained, or which are now being employed in putting it to practical use.

THE ETHER.

Sir Isaac Newton formulated a theory of light known as the corpuscular theory, according to which light was supposed to be due to very minute particles or corpuscles projected with enormous velocity from luminous bodies Newton adopted this merely as a working hypothesis which gave a fairly reasonable explanation of what was known of light, but he was by no means satisfied with it. It accounted for the ordinary phenomena of reflection and refraction, but in order to account even for the simpler phenomena of polarised light it was necessary to make various more or less complicated additional assumptions. Still for a long time the corpuscular theory found a number of adherents to maintain it against the theory developed by Huyghens and others that light was a wave motion, the great objection to the acceptance of the undulatory theory being the necessity of assuming the existence of a medium filling the whole space occupied by the visible universe and having properties of a character hitherto quite unfamiliar. It was not until it became possible to make comparative measurements of the velocity of light in media of varying density that the corpuscular theory was definitely overthrown, since it demanded that the speed of transmission of light should increase with the density of the medium, whereas it is found that it decreases as the density increases, as is required by the wave theory. Since then new phenomena have been predicted from the wave theory and experimentally verified, and the whole theory of spectrum analysis rests upon it, so that it, and therefore the existence of the luminiferous ether, is no longer regarded as a working hypothesis but as a fact, the evidence in its favour being quite as strong as that for the truth of Newton's law of Universal Gravitation.

At the present time we not only know that light and radiant heat are due to etheric vibrations but we know the exact nature of the vibrations, and as regards light we know the lengths of the waves corresponding to the various colours of the spectrum. We know, too, that heat waves are exactly similar to light waves except that they are of greater length, and the only reason that we cannot make measurements of heat waves with the same degree of accuracy as of light waves is that we have no special organ for the heat sense corresponding to the eye, which forms an instrument of extreme sensitiveness for light observations.

Sound waves are transmitted by ordinary matter, either solid, liquid or gaseous, and, as is well known, sound cannot be transmitted through a space which does not contain matter of very sensible density, a comparatively thin stratum of even such an imperfect vacuum as can be obtained by the aid of a good ordinary air-pump being sufficient to entirely stop it. When sound travels through a solid mass of matter the vibration takes place in all possible directions, but when it is transmitted through fluids, whether liquid or gaseous, the vibrations are entirely longitudinal, that is to say the motion of the moving particles is always parallel to the direction in which the sound is travelling. The reason of this is that while fluids possess volume

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elasticity, or resistance to change of volume, they have no rigidity, or resistance to change of shape, and substances without rigidity can only transmit longitudinal vibrations, the transverse vibrations being entirely due to resistance to shearing, that is, to the sliding of one portion of the substance over another.

It has long been known from the phenomena of light that the vibrations are entirely transverse, that is to say, any particle of the vibrating medium remains throughout its motion always in the plane perpendicular to the direction of transmission of the ray of light, the longitudinal vibrations being non-existent. No explanation of this suppression of the longitudinal vibrations was obtained until Maxwell showed theoretically that this was characteristic of electro-magnetic waves, and suggested the probability of light waves being simply electro-magnetic waves having wave lengths between the limits within which the human eye was capable of responding to them.

Between fifty and sixty years ago that great philosopher and experimentalist, Michael Faraday, seems to have had some kind or instinctive glimmering of an idea that there was some connection between electricity and light. In the then state of knowledge there was nothing apparently to warrant it, but he tried a number of experiments upon the effects of electric and magnetic fields upon rays of light before he obtained any result.

He allowed a beam of plane polarised light to pass through holes in the poles of a powerful electro-magnet, so that the direction of transmission of the ray was parallel to the lines of force of the magnetic field. A very dense kind of glass containing borate of lead, a glass which Faraday had himself discovered and made some years before, was then placed between the poles, when it was found that if an analyser was so arranged as to stop all the light before the magnet was excited, then on excitation taking place there was a slight brightening of the field which could be reduced to darkness again by slightly rotating the analyser.

Neither Faraday nor anyone else was able at the time to account for a fact obtained through the coincidence of a number of circumstances all requisite for success, though not one of them could have been predicted, and which furnishes a wonderful example of the thoroughness and utter disregard of repeated failures which was one of the leading characteristics of Faraday's experimental work.

The meaning of this experiment was first pointed out by Sir William Thomson, now Lord Kelvin, and its important consequences were fully investigated by Maxwell, who in all probability was led by it to formulate his electro-magnetic theory of light.

I have already pointed out that the vibrations forming a ray of light are all in a plane perpendicular to the direction of the ray. In general the vibrations take place in all possible directions in this plane, but it is possible by allowing a beam of light to pass through certain crystals, and by other means, to break up these vibrations in all possible directions in the plane into vibrations in two directions at right angles to each other, and it is further possible by simple means to get rid of one set of vibrations, leaving only vibrations which are all perpendicular to a plane containing the ray and which is known as the plane of polarisation, the light being said to be plane polarised.

Faraday's discovery was that it was possible by means of a magnetic field to produce rotation of the plane of polarisation.

Maxwell called attention to the fact that the observed velocity of light was, within the limits of errors of observation, identical with the rate of propagation of an electro-magnetic disturbance deduced theoretically from certain electrical measurements, and cited other experimental facts in its favour; and many other facts since discovered have confirmed Maxwell's conclusions, more particularly the work of Hertz, which I shall consider later in some detail, and in which he demonstrated experimentally that electro-magnetically excited waves could be made to interfere with each other and could be reflected and refracted exactly like light waves.

Heat and light are therefore found to be mere special cases of electro-magnetic waves which may vary through all gradations of wave lengths varying from thousands of miles down at any rate to a few hundred thousandths of an inch in the case of light waves, and the great electro-magnetic spectrum extends, we know, far beyond this, for we can detect by their effect on photographic chemicals the existence of waves far beyond the violet end of the spectrum, that is to say of waves shorter than the shortest light waves which the eye can perceive.

Lord Kelvin, in a paper published in the "Transactions of the Royal Society of Edinburgh" in May, 1854, has shown how a probable minimum limit may be assigned to the density of the ether.

The French physicist, Pouillet, as the result of a series of carefully-made measurements, had found that the heating effect of direct sunlight falling on a surface of a square centimetre at the distance of the earth from the sun amounted to 1.7633 gramme Centigrade units of heat per minute, or 1.234×10^6 ergs per second. This would evidently be the amount of energy due to sunlight contained in a prism with a base having an area of a square centimetre and with a height equal to the velocity of light in centimetres per second, viz., 3.004×10^{10}, which gives as the energy per cubic centimetre per second:

$$\frac{1.234 \times 10^6}{3.004 \times 10^{10}} = 4.1 \times 10^{-5} \text{ ergs.}$$

Lord Kelvin deduces from this datum a superior limit to the velocity of a vibrating particle of the medium transmitting radiant heat or light, on the assumption that the amplitude of vibration is a small fraction of the wave length and that the maximum velocity of a vibrating particle is small compared with the speed of propagation of waves. The first assumption is certainly justifiable, and the second follows from it, for considering the case of plane polarised light where the vibration is a simple harmonic one, if V be the velocity of wave transmission, v the maximum velocity of a vibrating particle, A the semi-amplitude or distance of the vibrating particle at the extremity of an excursion from the position of equilibrium, and λ the wave length, then it is known that

$$\frac{v}{V} = 2\pi \frac{A}{\lambda}$$

Now the whole mechanical energy of homogeneous plane polarised light in an infinitely small space containing only particles sensibly in the same plane of vibration is entirely potential when the particles are at rest at either end of an excursion, entirely kinetic when the particles are in the position of equilibrium, and partly potential and partly kinetic in all other cases.

This energy being constant in amount is equal to $\frac{1}{2} m v^2$, where m is the mass in vibration, for v is a maximum in

the position of equilibrium. If, therefore, ρ is the mass of vibrating matter in unit volume, or, in other words, the density of the matter, the mechanical value of the energy is $\frac{1}{2}\rho v^2$.

In the case of circularly polarised light, in which every particle describes a circle with constant velocity, the energy is half potential and half kinetic, so that if v is the constant velocity the energy is ρv^2.

In the case of elliptically polarised light, the value lies between the two. Moreover, for co-existent series of waves of different periods polarised in the same plane, the mechanical energy is the sum of the portions due to each, from which it follows that the maximum velocity is the sum of the separate velocities.

The same reasoning applies to circularly polarised light of different periods. It follows, therefore, that the mechanical energy must certainly be less than the product of half the mass into the square of the maximum velocity acquired by a particle in the case of plane polarised waves, and it may be concluded that for any radiation, unless homogeneously circularly polarised, the mechanical value of the disturbance is less than the product of the mass into the maximum velocity of a vibrating particle.

That is to say, 4.1×10^{-5} ergs is less than ρv^2, and therefore very much less than ρV^2, or ρ is certainly very much greater than $\dfrac{4.1 \times 10^{-5}}{(3.0004)^2 \times 10^{20}}$.

If we assume $V = 100\, v$, which is a reasonable one to make, then ρ comes out as somewhere about $\frac{1}{9} \times 10^{-21}$. Now the ratio of rigidity to density is equal to the square of the speed of transmission, which gives for the rigidity $\frac{1}{9} \times 10^{-21} \times 9 \times 10^{20}$, or about $\frac{2}{5}$. This is small compared to the density of any known solid. Steel is the most rigid substance known to us, and its rigidity is as high as 8×10^{11}.

It is not only in free space that luminous and other electrical vibrations are transmitted by ether. Water and other fluids, for example, transmit light, but it cannot be the fluid which acts as the medium, for it has no rigidity, and is therefore incapable of transmitting transverse vibrations. Even in transparent solids the waves must be transmitted by ether penetrating the interstices of the matter composing them, for the rate of transmission is far too great for the matter itself to be the medium.

The ether, however, within different kinds of matter is largely modified to an extent depending on the substance. For example, in heavy glass the speed of transmission of a luminous wave is only about two-thirds of the speed in free space. The ether must, therefore, either have its density increased or its rigidity diminished by the presence of the particles of glass.

Many considerations appear to me to favour the latter hypothesis in preference to the former one. If the ether is capable of having its density varied it must be compressible, and therefore its structure must be molecular, and these molecules must be elastic, and then if we are to adhere to our plan of assuming that every action between distant bodies is due to actual pushing or pulling of bodies actually in contact with them, we shall require a second ether to explain the elasticity of the molecules of the first.

We therefore seem to be driven to the conclusion that the ether is to be regarded as continuous and therefore incompressible, so that the modification of ether in contact with matter must consist in a diminution of rigidity and not in an increase of density.

This conclusion appears to me to be strongly confirmed by the simple explanation which it gives of opacity. There is no such thing as a perfectly opaque body, but some come very near it, and on our theory, which is practically that of McCullagh, the explanation is that in such bodies the rigidity of the ether approaches the vanishing point. If we adopted Fresnel's theory of the increase of density of ether in contact with matter we should have to suppose the density of the ether in practically opaque bodies to be increased to an enormous extent.

Another point in favour of this view is that if we assume with McCullagh that the diminution in rigidity is due to a sort of straining of the ether towards the particles of matter we get at something like the explanation of gravitation, for under those circumstances two bodies would tend to draw together. Objectors to the ether on the ground of the complication involved in the co-existence of two apparently so distinct things as matter and ether may be interested to learn that Lord Kelvin has suggested a simplification of a very beautiful character.

While fluids at rest have no rigidity, portions of them may become rigid by being set in rapid motion, as is well illustrated by the smoke rings which some smokers are very skilful in blowing from their mouths and which may easily be produced in air, water, and other fluids.

Lord Kelvin made the beautiful suggestion that the apparently unchangeable atoms of different kinds might simply be vortex rings of various shapes in the ether, which from this point of view must act as a perfect fluid.

Errata to last Article, p. 25, column 2, line 26, read "this medium is *relatively to its density* far more rigid than steel"; p. 26, column 2, line 13, for "electric bodies" read "electric waves."

DROPS AND THEIR SPLASHES.

THE beauty and scientific meaning of familiar phenomena cannot be gauged by popular views regarding them. It would be difficult to imagine anything more commonplace to the ordinary observer than the splash of a drop, yet Professor A. M. Worthington's researches, extending over many years as they have done, and the first series of which were but recently completed, show that this apparently simple occurrence, when examined by the refined methods which science makes possible, is really a succession of bewilderingly beautiful phases, which for their complete interpretation require the resources of higher mathematical analysis. The same distinguished investigator has demonstrated that a variety of allied phenomena, while fundamentally dependent upon the same properties of matter, are all characterized by their individual peculiarities of changing forms, which can be reproduced at will by the experimenter.

It is not necessary in this place to trace the development of the perfected form of apparatus used in the most recent experiments, for the steps by which the final disposition of the instruments was reached may be followed in the "Proceedings" and "Philosophical Transactions of the Royal Society." The essence of the problem which Prof. Worthington had to solve can be very briefly stated. How could a drop of definite size be allowed to fall from a known height in comparative darkness upon a surface, and be illuminated by a flash of exceedingly short duration at any desired instant, at any particular stage of the impact of the drop, so as to exclude all other stages previous and subsequent to

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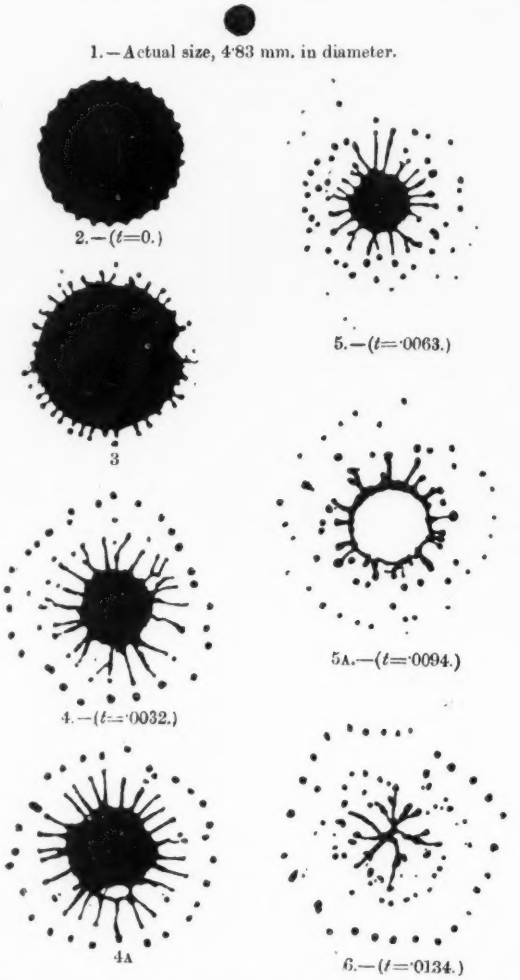
the one picked out? More than this, if necessary the experiment must be capable of repetition, with an exactly similar drop falling from exactly the same height, and illuminated at exactly the same stage. It must then be possible, after this particular stage has been sufficiently examined, to be able to arrange that a later stage, say one-thousandth of a second after the other, may be studied in the same manner as the earlier one, and in this way to follow step by step the course of the whole series of changes.

In his early observations, as no photographic plates were then available sufficiently sensitive to respond to the very short exposures that were required, Prof. Worthington had perforce to study the different stages by eye and make drawings of them. Though he was enabled by this means to trace with marvellous accuracy the complete splash, yet the application of the photographic method in more recent years has made it possible to confirm, to extend, and in some cases correct, the results of ocular observations. Following Prof. Boys' suggestion, who had in his popular flying bullet experiments used sensitive plates, Prof. Worthington and his colleague, Mr. R. S. Cole, employed Thomas's cyclist plates, with excellent results. To give an idea of the results of an extended series of experiments on splashes of a great many kinds, which have all been photographed and examined in the same systematic way, it will be best to select two typical instances for description. The two cases chosen, which are shown graphically in the accompanying illustrations, are, first, the splash of a drop of mercury 4.83 millimetres in diameter falling through fifteen centimetres upon a plate of glass; and second, of a large stone sphere 3.2 centimetres in diameter, falling through a height of 14 centimetres into water mixed with milk, contained in a glass bowl about one foot deep and nine inches in diameter.

The first set of pictures were obtained by allowing the drop of mercury to fall upon the naked photographic plate itself. The illuminating spark was produced vertically above the plate, and consequently the figures only show a horizontal section of the drop in various stages. Very soon after the first instant of impact minute rays are shot out in all directions. These are afterwards united, and then main rays shoot out (see Fig. 3), from the ends of which, in some cases, minute droplets of liquid split off, to be left lying in a circle on the plate and visible in all subsequent stages. Figs. 4, 4A and 5 show how the central mass contracts but leaves long arms or rays which contract more slowly. In Fig. 5A the thin film has torn open in the middle and yielded an annulus, which in turn would separate into a ring of drops surrounded by a second circle of the still smaller and more numerous droplets that split off the ends of the rays. It must be remembered that the interval of time during which all the stages shown in the figure are passed through is very small, being, as the numbers indicated show, only about the one-seventy-fifth part of a second.

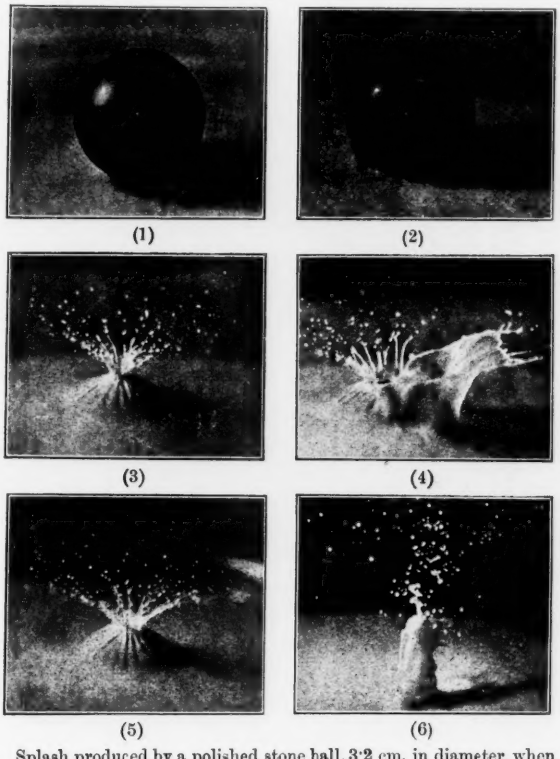
Before referring to the second series of photographs it is necessary to point out that the form of the splash in this case depends very much upon the condition of the surface of the sphere. When a polished sphere of marble, rubbed very dry with a cloth just beforehand, is dropped into water, the water spreads over the sphere so rapidly that it is sheathed with the liquid even before it has passed below the general level of the surface. The splash is insignificantly small and of short duration. But if the sphere be roughened with sand-paper or left wet, the water is driven away laterally, forming a ribbed basket-shaped hollow, which, however, is now prolonged to a great depth, the drop being followed by a cone of air, while the water seems to find great difficulty in wetting the surface of the sphere completely. The first photograph shows a highly polished sphere just before the impact with the liquid. The beginning of the rise of the sheath can easily be made out in the second



Instantaneous Shadow Photographs (life size) of the Splash of a Drop of Mercury falling 15 cm. on to Glass.

photograph, while the want of symmetry in the fourth stage depicted is due to the sphere having been rough on the right side and polished on the left. This photograph shows at a glance the great difference between a "rough" and a "smooth" splash. The puckering of the surface, which is strongly marked in the fifth photograph, indicates that the lines of flow near the surface of the liquid when once determined are very persistent. The general surface of the milk-and-water in the next stage is very level, while the volume of the column which can be very clearly seen is scarcely more than one tenth that of the sphere. This proves that there is an instantaneous general rise of level even at a great dis-

tance. The interval of time between the instant of impact and the form of the splash shown in the fifth



(1) (2) (3) (4) (5) (6)

Splash produced by a polished stone ball, 3·2 cm. in diameter, when falling into a basin of milk and water, from a height of 14 cm. Starting from the instant at which the sphere touched the surface of the liquid, the intervals of time that have elapsed, in fractions of a second, are as follows :—

(1) t = 0. The ball has just reached the liquid.
(2) t = ·0025 sec. Sheath of liquid beginning to rise.
(3) t = ·0080 sec. Ball already covered.
(4) t = ·0110 sec. Shows the effect of polishing the left side only, leaving the right side rough.
(5) t = ·0134 sec. Regularity restored by complete polishing.
(6) t = ·0242 sec. Column resulting from converging streams of liquid.

photograph when the sphere is completely covered was a little under one-seventy-fourth of a second.

The mechanics of the phenomena to which special attention has been thus briefly referred is a subject of too abstruse a nature to be gone into here, but the interested reader who wishes to become more intimately acquainted with these particularly interesting researches should make a point of studying the papers under Prof. Worthington's name in the Royal Society's "Proceedings" and "Transactions." The illustrations here reproduced show that the commonest occurrences may be made fruitful subjects of scientific analysis.

Microscopy.

By JOHN H. COOKE, F.L.S., F.G.S.

Dr. H. C. Sorby, F.R.S., contributes to the current issue of the *Journal of the Royal Microscopical Society* a paper on "The Preparation of Marine Worms as Microscopical Objects." With a view to preserving the minute blood vessels of *Nereis* from decomposition, the author experimented with many reagents, but rejected all of them in favour of glycerine. His method is, briefly, as follows :—Specimens measuring from two to three inches in length were killed by placing them in strong glycerine diluted with an equal volume of water, and were afterwards immersed in fresh water for ten minutes to eliminate the glycerine. They were then arranged on a microscope slide, and dried quickly in the open air at the ordinary temperature. A cell built of glass slips was attached to a slide, and the specimens were mounted in balsam and protected by a thin cover glass in the usual way. Dr. Sorby has specimens that were treated thus two years ago, and they not only show no signs of change, but the structure of the animal is more clearly defined in the preserved state than it is when the animal is alive or recently dead.

At a demonstration recently given before the Royal Microscopical Society of London, Dr. Spitta exhibited some very fine micro-photographic work which he had done with lenses by Zeiss, Powell, Beck, and Wray. He spoke very highly of the one-eighth apochromatic N.A. 1·40 by Zeiss, which he considers to be "the finest lens in the world" for micro-photography.

Mr. W. Colquhon has been experimenting with staining processes for the purpose of differentiating the canaliculi in bone. None of the usual methods gave satisfactory results, for though the nuclei of the bone corpuscles were stained, the outlines of the canaliculi were only faintly shown. Glass tubing was, therefore, arranged in lengths of twelve feet on a wall, and a bone with the head sawn off, the medullary cavity cleaned out and one end corked, was connected with the glass tube by means of a wide rubber tube. The periosteum was removed, and any holes visible on the outside were plugged with wooden pegs. The tubing was then filled the whole length with stain, to which a little antiseptic had been added. The bone being in a dry room, dried, and as this occurred the stain was drawn in to take the place of the evaporated moisture. After about a month all of the nuclei of the bone cells were found stained, and also the lining membranes of the canals. The bone matrix remained unstained, but the canaliculi were faintly outlined.

The new section of "Laboratory Photography," which has recently been included in the *Journal of Applied Microscopy*, is both interesting and useful. Among many articles bearing on the methods and technique of microscopy is a suggestive paper on "Practicable Photo-micrography," by Mr. C. Potter, and a note by Mr. W. E. Britton on "The Ray Filter in Laboratory Photography."

An electric microscope lamp has recently been placed on the market by Messrs. J. Swift & Son. It was designed by Mr. J. E. Barnard to give an evenly illuminated field in the microscope, without the image of the filament of the incandescent lamp being thrown up from the mirror in the field of view. This is effected by a light from the incandescent filament falling upon a flat plane placed at an angle of 45° to the axis of the lamp, and the surface of which is covered with a preparation which throws off an intensely white light in such volume that the largest mirror of any microscope can be fully illuminated. The lamp is mounted on a swivel, enabling it to be placed at any angle, and can also be lowered or raised at will.

The focussing of a microscopic object on a ground glass screen requires much skill and care. The screen which is supplied with the ordinary camera is generally too coarse, and in high power photo-micrography even the finest ground glass obtainable does not always give satisfactory results. For critical and medium work it is essential that the focussing screen should be, as far as possible, without grain. A simple way of preparing such a screen is as follows:—Take an unexposed photographic dry plate and immerse it in a solution of chloride of barium for ten minutes. Transfer it to a bath of dilute sulphuric acid and gently rock the solution to and fro until a fine, even precipitate of barium sulphate has been deposited. Wash and dry the plate, and it will be ready for use.

Another method, recommended by Prof. Gage and others, is to find the centre of the ground glass screen and then to place a large circular or square cover-glass on it with Canada balsam. To do this, warm the ground glass carefully, add a drop of rather thick balsam to the centre on the ground side, and then apply the cover and press it down firmly. Put it away on a warm shelf for a few days to harden, after which the excess of balsam may be removed from the edges with the aid of a penknife and xylen or alcohol. The balsam will fill up the inequalities in the glass, and being of about the same refractive power will make this part of the glass clear as if it were unground. The focussing

screen as thus prepared with a clear centre, serves both for the general focussing and the finest focussing, and avoids the danger of using the double screen.

For the photography of opaque substances, such as metals, &c., a metal microscope, such as that which is made by Reichert, of Vienna, is necessary. The microscope must be fixed in an upright position, and reflected light used. The source of light should be at a distance of one to one and a half metres from the apparatus, and must be on the same level as the reflecting lens at the side of the vertical illuminator on the tube of the microscope. The specimen should be everywhere equally illuminated and then focussed. Eosin plates and the use of a yellow screen are to be recommended for this work.

The selection of plates and screens for photo-micrography is a subject upon which we propose to say more in future issues. The following points are of practical importance, and should receive careful attention:—For stained preparations orthochromatic plates give the best results, but it is of advantage to place a screen, complementary in colour to the stain used, between the source of light and the microscope. Generally speaking, a light filter of picric acid should be used for specimens stained dark red, or violet; for light red stains, a greenish-yellow one; and for preparations stained with methylene blue, a dark orange-yellow filter is recommended.

[*All communications in reference to this Column should be addressed to Mr. J. H. Cooke at the Office of* KNOWLEDGE.]

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

THE DISCOVERY OF COMETS.—In the century from 1700 to 1799 inclusive 64 comets were discovered and observed sufficiently well for their orbits to be computed. The average rate of discovery was therefore 0.64 annually or about two comets every three years. A vast increase in the number of these discoveries is shown by the figures for the century from 1800 to 1899. 315 comets were found, including redetections of periodical comets, so that the annual average was 3.15. Comparing the first with the last half of the century the numbers were—

	Comets found.	Annual average.
1800 to 1849 ...	... 91 ...	... 1.8
1850 to 1899 ...	... 224 ...	... 4.5

There were comparatively few comets found before 1840, but in that year and the few ensuing ones a marked rise occurred, and observers have been very successful in this field ever since. The numbers of comets discovered in the various months of the year during the period 1800-1899 were as follows:—

January ...	... 17	July ...	... 35
February ...	... 19	August	... 40
March ...	... 24	September	... 25
April ...	... 27	October	... 26
May ...	... 20	November	... 31
June ...	... 28	December	... 23

Of the spring months March and April show the best returns. In the summer there is a rapid rise from June to August, the latter being apparently the best month of the year for sighting new comets. In the autumn, November has a good record, notwithstanding the unfavourable weather often prevailing at this period.

GIACOBINI'S COMET.—During the coming summer cometary observers will have an interesting object for study though it will be by no means bright. It will, however, occupy an extremely favourable position in the sky during the four months June to August inclusive. At the end of May the comet will become visible in the morning sky, being placed in the N.E. extremity of Pisces and about 7 degrees south of Beta Andromedæ. Thence it moves to the north-west, and early in July will be found in the left hand of Andromeda, near Nu, Chi, Psi, and Lambda in that constellation. It afterwards traverses Lacerta and Cygnus, passing near Alpha, and at the end of July will be about 2 degrees south of Delta. Passing then through Lyra it enters the eastern borders of Hercules, and will be near Alpha Ophiuchi at the middle of September. But its great increase of distance will now have rendered it faint, and its motion south will carry it out of sight altogether. Our last number contained an outline ephemeris by Berberich, and it is intended to give its path with more detail so that the object may be attentively followed during ensuing months.

STATIONARY RADIATION OF METEORS.—This may be said to form one of the moot points of astronomy. It is not a discordance between rival observers, but a difficulty of explaining observed facts on approved mathematical theories. In 1878, when fixed or recurring radiants were brought prominently into notice, it was asserted that they must be due to successive but different showers accidentally grouped in such a manner as to render their apparent directions almost identical. But observation showed that this idea did not satisfactorily account for the facts because the points of divergence remained constant (allowing for small and unavoidable errors of observation), and that there were no such differences as a mere chance grouping of streams must certainly occasion. Wherever a radiant is placed relatively to a neighbouring star there it remains during the whole period of its visible activity, and this often covers several months. Of late several able mathematicians have attacked the matter, and valuable papers have appeared from Profs. A. S. Herschel, H. H. Turner, and G. von Niessl, Dr. Bredikhine, and M. O. Callandreau. Prof. Turner has offered a very ingenious explanation of stationary radiation ("Monthly Notices," Jan., 1899), on the basis of planetary perturbation operating through vast intervals of time upon meteoric particles, and the observed peculiarity seems in a fair way of being understood. More observations would be very valuable. Very few astronomers have ever practically investigated the matter, for the reason that it requires a vast number of very accurate materials before any satisfactory tests can be applied as to the stationary aspect of the minor showers generally. Instead of examining the whole question it would be better to select a test case, say that supplied by the Orionids of October. If this notable autumn shower were attentively watched between October 12 and 25 and the radiant independently determined on each night it would be easily seen whether the radiant were stationary. And if one well known shower is found perfectly stationary during a fortnight there can be no reason why other showers may not present a similar aspect during even longer intervals.

MAY METEORS.—The spring season may be described as one of meteoric scarcity. The Aquarids, sometimes visible in the morning twilight, and possibly associated with Halley's comet, furnish, however, an interesting system which well deserves looking for. It furnishes fine long meteors with streaks during the first week in May, but they are only perceptible just before daylight as the radiant is below the horizon in the early part of the night.

FIREBALL, MARCH 28TH, 8H. 31M.—A large meteor giving two outbursts like vivid lightning flashes was seen by Mr. G. T. Davis at Reading. He says it passed from near Cor Caroli towards Denebola, but described a curve ending near Epsilon Virginis. It exploded twice, finally breaking up into sparks. The meteor lit the place up. Mr. T. H. Astbury, of Wallingford, writes that he was looking north at the time, and only saw the brilliant flashes of light which the meteor occasioned. From inquiry afterwards he found that the meteor's apparent path was from about 188° + 18° to 193° − 6°, and that it was very much brighter than the planet Venus.

THE FACE OF THE SKY FOR MAY.

By A. FOWLER, F.R.A.S.

THE SUN.—On the 1st the sun rises at 4.33 and sets at 7.21; on the 31st he rises at 3.51 and sets at 8.3. One of the most striking astronomical events of the year will be the eclipse of the sun on the 28th. Full particulars as to the parts of the earth's surface from which the total phase will be visible are given by Mr. Maunder in the March number of KNOWLEDGE. Over the British Islands a large partial eclipse will be visible, the data given in the *Nautical Almanac* being as follows:—

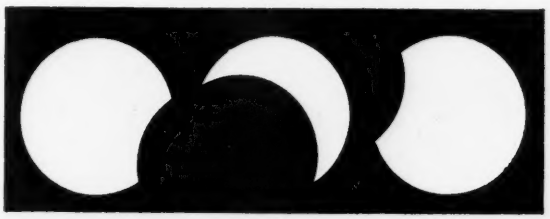
Place.	Magnitude.	Begins.	Angle from North.	Angle from Vertex.	Greatest Phase.	Ends.	Angle from North.	Angle from Vertex.
			°	°			°	°
Greenwich ...	0.681	2.47	108 W.	146 W.	3.55	4.58	111 E.	69 E.
Cambridge ...	0.664	2.47	109 W.	146 W.	3.54	4.56	112 E.	70 E.
Oxford ...	0.683	2.45	108 W.	145 W.	3.54	4.57	111 E.	69 E.
Liverpool ...	0.656	2.42	110 W.	143 W.	3.50	4.53	112 E.	72 E.
Edinburgh ...	0.599	2.41	114 W.	144 W.	3.48	4.47	115 E.	78 E.
Dublin ...	0.676	2.38	109 W.	141 W.	3.47	4.52	111 E.	71 E.

All the times above are expressed in Greenwich Mean Time, and are P.M.; the position angles of the contacts are for direct image.

Three phases of the eclipse at Greenwich are illustrated in the accompanying diagram, which is constructed with the vertex at the top in each case.

XUM

ECLIPSE OF THE SUN, MAY 28TH, 1900,
as it will appear in London.



3 P.M. 3.55 P.M. 4.45 P.M.

Eclipse begins, 2.47 P.M. Eclipse ends, 4.57 P.M.

THE MOON will enter first quarter on the 6th at 1.39 P.M.; will be full on the 14th at 3.37 P.M.; will enter last quarter on the 21st at 8.31 P.M.; and will be new on the 28th at 2.50 P.M. The solar eclipse on the 28th will furnish a good opportunity of observing the Moon's limb.

The principal occultations during the month are as follows:—

Date.	Name.	Magnitude.	Disappearance.	Angle from North.	Angle from Vertex.	Reappearance.	Angle from North.	Angle from Vertex.	Moon's Age.
				°	°		°	°	d. h.
May 1	ι Tauri	4·7	8.58 P.M.	110	71	9.48 P.M.	259	224	2 16
,, 5	A^2 Cancri	5·6	11.48 P.M.	124	84	12.42	277	240	6 19
,, 6	ω Leonis	5·6	11.1 P.M.	79	40	11.51 P.M.	329	290	7 18
,, 7	19 Sextantis	6·0	10.43 P.M.	127	93	11.49 P.M.	285	247	8 18
,, 19	B.A.C. 6707	6·2	12.39 A.M.	22	49	1.18 A.M.	315	337	19 20

THE PLANETS.—Mercury is a morning star until the 30th, when he is in superior conjunction. He is not well placed for observation in our latitudes. He will be very close to the sun during the total eclipse on the 28th.

Venus remains an evening star throughout the month, and will reach her greatest brilliancy at the end. The apparent diameter will increase from 24″·2 on the 1st to 36″·4 on the 31st, and on the 15th the illuminated portion of the disc will be 0·402. The path of the planet is easterly through Gemini. The planet will be near to Epsilon Geminorum on the 14th and 15th, about 1½° to the north, and a little over 3° to the north of Delta on the 27th.

Mars is a morning star, not well placed for observation.

Jupiter will be in opposition on the 27th. On the 1st he rises about 9.45 P.M., and crosses the meridian shortly before 2 A.M. On the 31st he rises at 7.31 P.M., and crosses the meridian at 11.39 P.M. The apparent diameter is 41″ on the 1st, and 42″ on the 31st. On account of his southerly declination of nearly 21°, the planet only reaches a low altitude, even when on the meridian. The path is a westerly one, a few degrees north of Antares. The satellite phenomena are most interesting on the 3rd, 7th, 10th, 16th, 17th, 18th, 19th, 23rd, 26th and 27th.

Saturn rises shortly before midnight on the 1st, and a little before 10 P.M. on the 31st. The planet describes a short westerly arc a little north of Lambda Sagittarii. The apparent polar diameter increases from 16″·2 to 16″·8 during the month; the ring is widely open, and its northern surface is presented to us.

Uranus rises about 10 P.M. at the beginning, and about 8 P.M. at the end of the month. The planet traverses a short westerly path, about 2½° east of Jupiter, on the 1st, and about 5° east on the 31st.

Neptune sets about 11 P.M. on the 1st, and a few minutes after 9 P.M on the 31st. He is nearly midway between Zeta Tauri and 132 Tauri.

THE STARS.—About 10 P.M., at the middle of the month, Spica Virginis will be due south, Arcturus a little east of south, Ursa Major nearly overhead, Scorpio rising in the south-east, Vega pretty high up in the east, Cygnus north-east, Leo in the south-west, and Gemini a little north of west.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of April Problems.

No. 1.

(W. Gleave.)

1. Kt (Q5) to K3, and mates next move.

No. 2.

(H. A. Wood.)

1. R to QB5, and mates next move.

CORRECT SOLUTIONS of both problems received from W. Nash, Alpha, G. A. Forde (Capt.), H. S. Brandreth, W. de P. Crousaz, K. W., J. W. Meyjes, J. Baddeley, H. Le Jeune. Of No. 2 only, from W. A. Rogerson.

B. G. LAWS.—Many thanks for your three-mover. It is marked to appear in the June number.

K. W.—Mr. Rayner's book is entitled "Chess Problems, their Composition and Solution." Price 1s. The publishers are Messrs. Swan Sonnenschein & Co., Paternoster Square, E.C. I am indebted for this information to Mr. B. G. Laws, the author of "The Two-move Chess Problem."

W. PARKINSON.—If (No. 1) Q × B, R moves, there is no mate at QB2, as the Pawn can cover. In No. 2, 1. Q to Q7 is answered by P to K7 or other equally good defences.

W. A. ROGERSON.—Q × Kt very nearly solves No. 1, but 1 . . . R to B3 just prevents it, as Kt × R is not mate. Your notation is quite correct.

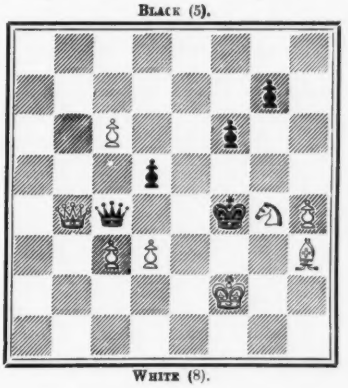
H. D. DRYERRE, Junr.—See reply above.

PROBLEMS.

No. 1.

By N. M. Gibbins (Repton).

BLACK (5).



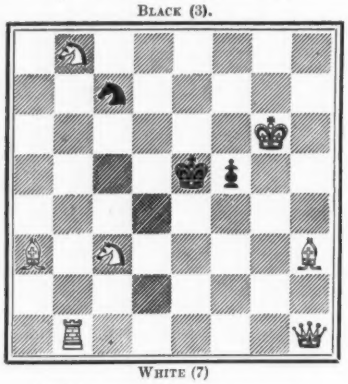
WHITE (8).

White mates in two moves.

No. 2.

By W. Clugston (Belfast).

Black (3).



White (7)

White mates in two moves.

CHESS INTELLIGENCE.

The Inter-University Chess Match resulted in a not unexpected win for Cambridge by five games to 2. The teams being as under:—

Oxford.		Cambridge.	
1. F. Soddy (Merton) ...	0	C. Tattersall (Trinity) ...	1
2. A. George (New College)	0	H. G. Softlaw (Trinity Hall)	1
3. G. Ellis (Lincoln) ...	0	C. Wiles (St. John's) ...	1
4. H. Wilton (Magdalen) ...	1	E. Coleman (Trinity) ...	0
5. F. Babcock (Wadham) ...	1	W. Burnell (Caius)	0
6. H. Arthur (New College)	0	J. Wright (Trinity)	1
7. G. Waterfield (Christ Ch.)	0	W. Ostle (Jesus)	1
	2		5

The Anglo-American Cable Match took place on March 23rd and 24th, and resulted, as last year, in a victory for the American team by 6 games to 4. Should they succeed in winning again next year, they will retain possession of the Newnes Trophy. Appended is the score, and a brief description of the games.

America.		Great Britain.	
1. H. N. Pillsbury ...	½	J. H. Blackburne ...	½
2. J. W. Showalter ...	½	F. J. Lee	½
3. J. H. Barry	1	H. E. Atkins	0
4. A B. Hodges ...	1	G. E. H. Bellingham ...	0
5. E. Hymes	½	D. Y. Mills	½
6. H. Voight	1	T. F. Lawrence	0
7. F. J. Marshall ..	0	E. M. Jackson	1
8. S. W. Bampton ...	0	Herbt. Jacobs	1
9. C. J. Newman ...	½	W. Ward	½
10. E. Delmar	1	H. W. Trenchard	0
Total	6	Total	4

Board No. 1.—Mr. Blackburne defended with an original variation of Philidor's defence, which cost him a clear Pawn very early in the game. After the exchange of Queens he manœuvred his minor pieces with such skill that a win appeared at one time within the bounds of possibility. Mr. Pillsbury, however, succeeded in escaping with the loss of a Pawn, and equality finally resulted.

Board No. 2.—Mr. Lee played the Stonewall attack, and having compromised his game on the King's side, was compelled to Castle on the other wing, where he was subjected to a violent attack. He defended himself skilfully, and judiciously submitted to the loss of the exchange in return for two Pawns, remaining finally with none the worst of the ending.

Board No. 3.—Mr. Atkins played an old-fashioned Sicilian defence, and obtained an early attack on the King's side. In endeavouring to make too much of it he exposed his King to the assault of Queen and Queen's Bishop, Mr. Barry soon forcing the position by the entry of a Rook at Q6.

Board No. 4.—Mr. Bellingham obtained considerably the best position in a Queen's Gambit, declined and was tempted to indulge in a promising Pawn sacrifice. Mr. Hodges, however, defended very patiently, and finally won another Pawn and the game.

Board No. 5.—Mr. Mills, defending with the Sicilian, soon became subjected to a violent attack, which he nevertheless managed to survive. Though two Pawns to the bad, he contrived to remain with Bishops of opposite colours, and so drew without difficulty.

Board No. 6.—Mr. Lawrence obtained a good game against his opponent, Sicilian defence, but, after losing a Pawn owing to a mistake, his game broke up with great rapidity.

Board No. 7.—Mr. Jackson, defending the Lopez with Kt to B3 and B to K2, obtained a slight advantage in the end-game. The positions, however, were practically even when Mr. Marshall exceeded his time-limit and so lost the game.

Board No. 8.—Mr. Jacobs won a Pawn very early from his opponent, who declined the King's Gambit, and afterwards made a very weak defence, allowing the English player to wind up with a pretty sacrificial combination.

Board No. 9.—Mr. Ward declined the Queen's Gambit in the normal manner. Pieces were rapidly exchanged, and the defending player was left with a weak Pawn at K5. As, however, White could not attack it without exposing his King, a draw was speedily agreed on.

Board No. 10.—Mr. Trenchard played the Stonewall opening, and, after the Queen's side was blocked, became subject to a King's side attack. He lost the exchange, but owing to the peculiar situation of Mr. Delmar's Pawn it was some time before he found an opportunity of finally breaking through.

Mr. Burn succeeded in winning three consecutive games in his match with Mr. Bellingham, and so retrieving his lost reputation, the match being left drawn with the score standing at 4½ all.

Mr. T. F. Lawrence has won the championship of the City of London Club for the fourth time. His score was 14½ out of a possible 17. Mr. W. Ward was a very good second, only half a point behind; Mr. E. O. Jones being third with 11½. Mr. Lawrence has been singularly unfortunate in the cable matches, having lost his game on all three occasions on which he has played.

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